AEROSPACE REPORT NO.
TOR-95(5478)–4

DMSP F08 TILT EXPERIMENT DATA ANALYSIS STATUS BRIEFING

1 March 1995

Prepared by

Samuel D. Gasster
Radar and Signal Systems Department
and
Donald J. Rudy
Sensing and Exploitation Department
Electronic Systems Division

Prepared for

SPACE AND MISSILE SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
2430 E. El Segundo Boulevard
Los Angeles Air Force Base, CA 90245

Contract No. F04701-93-C-0094

Programs Group

Distribution authorized to U.S. Government Agencies and their contractors; administrative or operational use; 1 March, 1995. Other requests for this document shall be referred to DOD SMC/CIB.

DESTRUCTION NOTICE: For classified documents, follow the procedures in DOD 5200.22-M, Industrial Security Manual, Section 11-19 or DOD 5200.1-R, Information Security Program Regulation Chapter IX. For unclassified, limited documents, destroy by any method that will prevent disclosure of contents or reconstruction of the document.

THE AEROSPACE CORPORATION
El Segundo, California

AEROSPACE REPORT NO.
TOR-95(5478)–4

DMSP F08 TILT EXPERIMENT DATA ANALYSIS STATUS BRIEFING

Prepared by

Samuel D. Gasster
Radar and Signal Systems Department
and
Donald J. Rudy
Sensing and Exploitation Department
Electronic Systems Division

1 March 1995

Programs Group
THE AEROSPACE CORPORATION
El Segundo, CA 90245-2691

Prepared for

SPACE AND MISSILE SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
2430 E. El Segundo Boulevard
Los Angeles Air Force Base, CA 90245

Contract No. F04701-93-C-0094

AEROSPACE REPORT NO.
TOR-95(5478)–4

DMSP F08 TILT EXPERIMENT DATA ANALYSIS STATUS BRIEFING

Prepared by

Samuel D. Gasster
Radar and Signal Systems Department
Electronic Systems Division

Donald J. Rudy
Sensing and Exploitation Department
Electronic Systems Division

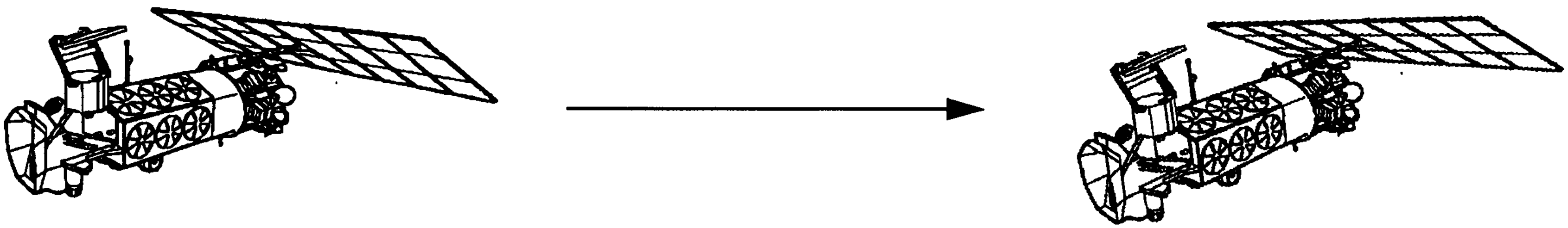
Approved by

Robert De Lorenzo, Principal Director
Defense Meteorological Satellite Program Directorate
MILSATCOM Division
Programs Group

M. L. Bolla, Principal Director
Sensor Systems Subdivision
Electronic Systems Division
Engineering and Technology Group

This report is based on preliminary investigations and is therefore of limited interest. The information presented is tentative and subject to modifications. The material is presented in order to provide initial results to various organizations which may utilize this information.

DMSP
F08 TILT EXPERIMENT
DATA ANALYSIS
STATUS BRIEFING



SAMUEL GASSTER

DON RUDY

ANDREW BUSTILLOS

SENSOR SYSTEMS SUBDIVISION

ELECTRONIC SYSTEMS DIVISION

FEBRUARY 24, 1995

THE AEROSPACE CORPORATION

EXECUTIVE SUMMARY

THIS BRIEFING SUMMARIZES THE RESULTS OF THE AEROSPACE CORPORATION'S DATA ANALYSIS IN SUPPORT OF THE F08 TILT EXPERIMENT. THE GOAL OF THE F08 TILT EXPERIMENT WAS TO ACQUIRE SPACEBORNE MICROWAVE RADIOMETER MEASUREMENTS AT HIGH EARTH INCIDENCE ANGLE (EIA) TO SUPPORT DEVELOPMENT OF FUTURE MICROWAVE REMOTE SENSING SYSTEMS FOR DMSP. SPECIFICALLY, THESE MEASUREMENTS WILL AID IN THE UNDERSTANDING OF THE PASSIVE REMOTE SENSING OF THE EARTH'S SURFACE AT HIGH EIA IN ORDER TO ACHIEVE CONTIGUOUS EQUATORIAL SWATHS.

THE F08 TILT EXPERIMENT WAS CONDUCTED DURING JUNE AND JULY OF 1993. THE PRIMARY DATA COLLECTION SITE WAS THE FLEET NUMERICAL OCEANOGRAPHY CENTER, MONTEREY, CA. THE DATA COLLECTION CONSISTED OF SPECIAL SENSOR MICROWAVE/IMAGER (SSM/I) DATA FROM THE DMSP F08, F10 AND F11 SPACECRAFT. THE F08 SPACECRAFT WAS COMMANDED TO VARIOUS PITCH OFFSETS TO ACHIEVE THE REQUIRED HIGH EIA DURING THE TEST PERIOD. THE HIGH EIA F08 DATA IS THEN COMPARED AGAINST SPATIALLY AND TEMPORALLY COINCIDENT F10 OR F11 DATA POST TEST. THE DATA COLLECTION PHASE WAS EXTREMELY SUCCESSFUL.

THE DATA ANALYSIS DISCUSSED IN THIS STATUS BRIEFING COMPARES THE F8 AND F11 SSM/I DATA FOR THE BASELINE (PITCH=0°) AND HIGHEST EIA (EIA=69°, PITCH =-10.65°) CASES. BRIGHTNESS TEMPERATURES FROM THE COINCIDENT REGIONS ARE COMPARED AND STATISTICAL ANALYSES PERFORMED. THE MEANS FOR THE 19V,H, 22V AND 37V,H GHz CHANNELS ARE COMPARED (THE 85 GHz CHANNEL ON THE F08 SSM/I IS DEAD). THE RESULTS FOR THE BASELINE CONFIRM PREVIOUS COMPARISONS PERFORMED BY NRL, WHILE THE HIGH EIA DATA SHOWS STRONG CORRELATION BETWEEN THE F08 AND F11 BRIGHTNESS TEMPERATURES.

FURTHER ANALYSIS REMAINS TO BE PERFORMED AND IS DISCUSSED AT THE END OF THE BRIEFING. HOWEVER, THE RESULTS REPORTED HERE PROVIDE ENCOURAGEMENT THAT PASSIVE MICROWAVE REMOTE SENSING AT THESE HIGH EARTH INCIDENCE ANGLES SHOULD BE FEASIBLE.

ACKNOWLEDGMENTS

- DEDICATION
  - DR. JIM HOLLINGER, NRL
  - DR. VINCE NOBLE, NRL

- SUPPORT
  - FNOMC, DR. MARIE COLTON AND OTHER FNOMC STAFF HELPED MAKE THE F08 TILT EXPERIMENT DATA ACQUISITION A SUCCESS
  - NRL, MR. GENE POE PROVIDED SUBSTANTIAL SUPPORT DURING ALL PHASES OF THE F08 TILT EXPERIMENT AS WELL AS HIS EXPERTISE IN MICROWAVE REMOTE SENSING
  - MMAS TEAM FOR MAKING THE F08 SATELLITE “DANCE” SO DIVINELY
  - USAF SMC & 6SOPS, IN PARTICULAR CAPT.’S VASQUEZ AND ROCHIER
  - DMSP PO: ROBERT DE LORENZO & BILL WAGONER
  - DAVID GLACKIN - PRIME MOVER WHO REALLY HELPED GET THINGS DONE

- MR. VERN OLSON
  - FOR ORIGINALLY CONCEIVING THE F08 TILT EXPERIMENT

TOPICS

- BACKGROUND AND MOTIVATION
- SUMMARY OF F08 TILT EXPERIMENT
- ANALYSIS OUTLINE
- TDR TO SDR CONVERSION
- SUPPORT TO CONTRACTORS
- GEOLOCATION
- EDR GENERATION
- MODEL PREDICTIONS
- COMPARISON OF F08 AND F11 DATA
- PLANS FOR FINISHING DATA ANALYSIS

BACKGROUND

- **WHAT IS THE F08 TILT EXPERIMENT?**
  - EXPERIMENT TO COLLECT PASSIVE MICROWAVE SIGNATURES OF THE EARTH AT HIGH EARTH INCIDENCE ANGLES (EIA)
  - USED EXISTING MICROWAVE RADIOMETER ON DEFENSE METEOROLOGICAL SATELLITE PROGRAM F08 SPACECRAFT
    - » SPECIAL SENSOR MICROWAVE/IMAGER (SSM/I)
  - COLLECTED DATA FROM F08 AT HIGH EIA BY CHANGING SPACECRAFT PITCH ANGLE
  - COLLECTED SPATIALLY & TEMPORALLY COINCIDENT DATA FROM THE SSM/I ON THE F10 AND F11 SPACECRAFT FOR COMPARISON WITH F08 DATA
  - EXPERIMENT WAS CONDUCTED DURING JUNE/JULY 1993
  - PRESENTLY ANALYZING DATA
  - INITIAL RESULTS REPORTED HERE

- **AEROSPACE ROLE**
  - DEVELOPED INITIAL CONCEPT
  - DEVELOPED EXPERIMENT PLAN
  - PERFORMED EXPERIMENT IN CONJUNCTION WITH AF, NAVY AND CONTRACTOR SUPPORT
  - LEAD ROLE IN DATA ANALYSIS

MOTIVATION

- **WHY DID WE DO THE F08 TILT EXPERIMENT (F08TEX)?**
  - DMSP BLOCK 6 REQUIREMENTS: 6 hr REFRESH
  - DESIRE FOR CONTIGUOUS EQUATORIAL COVERAGE TO OBSERVE AND TRACK TROPICAL STORMS
  - FUTURE MISSIONS SUPPORT: EIA DESIGN REQUIREMENTS

- **WHAT CAN WE LEARN FROM THE F08TEX?**
  - CONFIRM
    - » GENERAL BEHAVIOR OF T_B WITH EIA
    - » GENERAL BEHAVIOR OF T_B WITH WIND SPEED AT HIGH EIA
  - DETERMINE
    - » ANOMALOUS BEHAVIOR OR "SURPRISES" AT HIGH EIA

- **WHAT THE F08TEX WON'T TELL US!**
  - BEHAVIOR OF T_B AT FREQUENCIES ABOVE 37 GHz
    - » 85 GHz CHANNEL ON F08 SSM/I DEAD
  - ANYTHING ABOUT EIA>69°
  - LARGE FOOTPRINT SIZE AT HIGH EIA FOR PITCHED SSM/I DOES NOT DIRECTLY RECREATE SAMPLING AND HORIZONTAL SPATIAL RESOLUTION FROM PROPERLY DESIGNED MW IMAGER FOR HIGH EIA

T_B = BRIGHTNESS TEMPERATURE = MEASURE OF MICROWAVE RADIANCE

MICROWAVE IMAGER COVERAGE

- **AEROSPACE ANALYSIS OF MICROWAVE IMAGER COVERAGE**
- **ASSUMED SCAN ANGLE OF 143.2°**
  - larger than SSM/I, but similar to SSM/IS
- **FIGURE 1**
  - H = 833 KM , INCLINATION =98.7431°, NA = 45°, EIA = 53.1°
  - SWATH WIDTH = 1706 KM (61.73% OF CONTIGUOUS COVERAGE)
- **FIGURE 2**
  - H=833 KM , NA = 55.34°
  - EIA = 68.43°
  - CONTIGUOUS COVERAGE
- **FIGURE 3**
  - H = 1390 KM, NA = 45°
  - EIA = 59.44°
  - CONTIGUOUS COVERAGE
- **CONSTRAIN SWATH WIDTH TO GIVE CONTIGUOUS COVERAGE**
  - FIGURE 4 & 5 SHOW IMPACT ON EIA OF VARYING ALTITUDE

H (KM)	EIA
1515	58°
2091	53°

MICROWAVE IMAGER COVERAGE

FIGURES 1-5 SHOW THE EFFECTS OF EIA AND ALTITUDE ON THE SWATH WIDTH AND COVERAGE OF A CONICAL SCANNING MICROWAVE IMAGER(MI). THE CASE CONSIDERED IS A MICROWAVE IMAGER WITH A SCAN ANGLE (ACTIVE PORTION OF THE SCAN) OF 143.2°.

TABLE 1 SUMMARIZES THE VARIATION OF ALTITUDE (H), SENSOR NADIR ANGLE (NA), AND EARTH INCIDENCE ANGLE (EIA) FOR EACH FIGURE AND WHETHER OR NOT CONTIGUOUS EQUATORIAL COVERAGE IS ACHIEVED .

FIGURE 1 ILLUSTRATES THE BASELINE CONFIGURATION SIMILAR TO THE SSM/IS PERFORMANCE.

FIGURES 2 & 3 ILLUSTRATE THE IMPACT OF TRADING OFF H AND EIA TO ACHIEVE CONTIGUOUS COVERAGE.

FIGURES 4 & 5 ILLUSTRATE THE IMPACT ON H AND EIA OF IMPOSING THE CONSTRAINT OF CONTIGUOUS EQUATORIAL COVERAGE.

FIGURE	H (KM)	NA (D)	EIA (DEG)	SWATH (KM)	CONTIGUOUS
1	833	45	53.1	1706	N
2	833	55.3	68.4	2763	Y
3	1390	45	59.4	3048	Y
4	1515	43.26	58	3111	Y
5	2091	36.97	53	3381	Y

MICROWAVE IMAGER COVERAGE

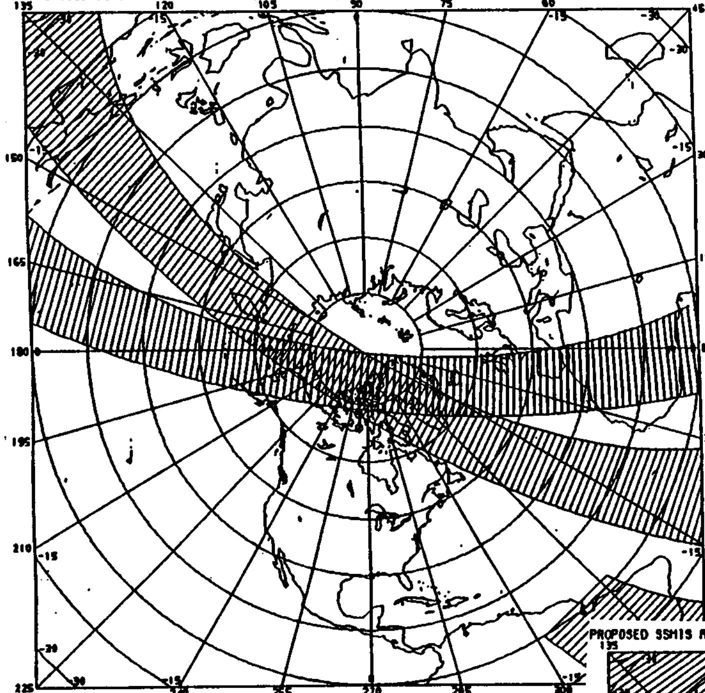


FIGURE 1

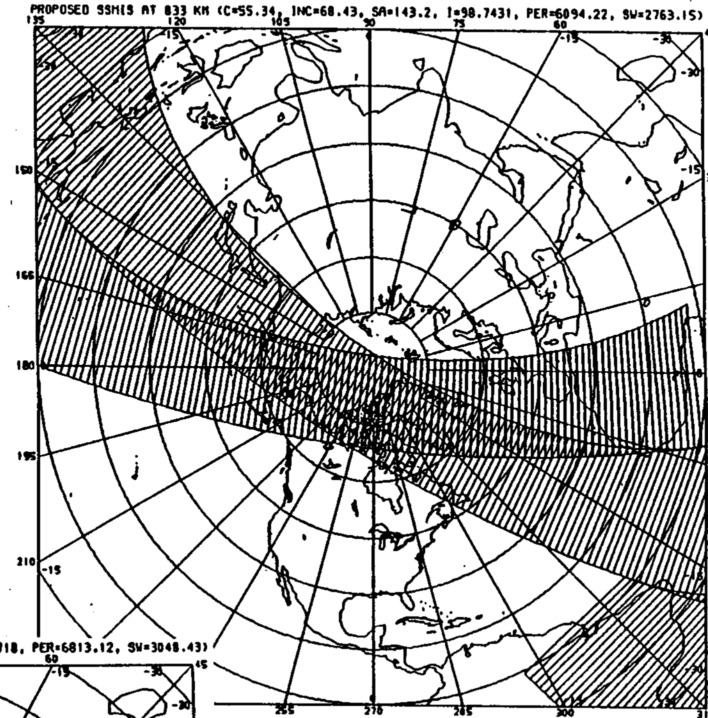


FIGURE 2

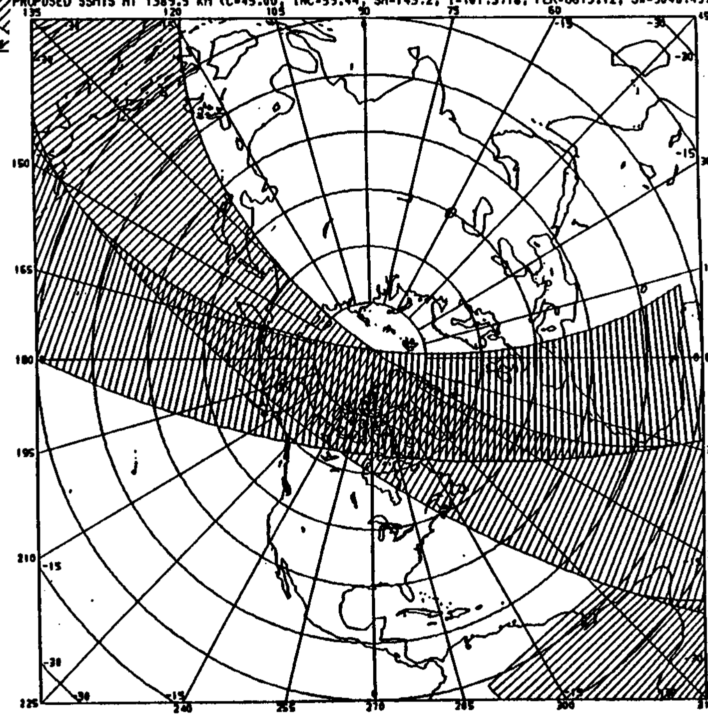


FIGURE 3

MICROWAVE IMAGER COVERAGE

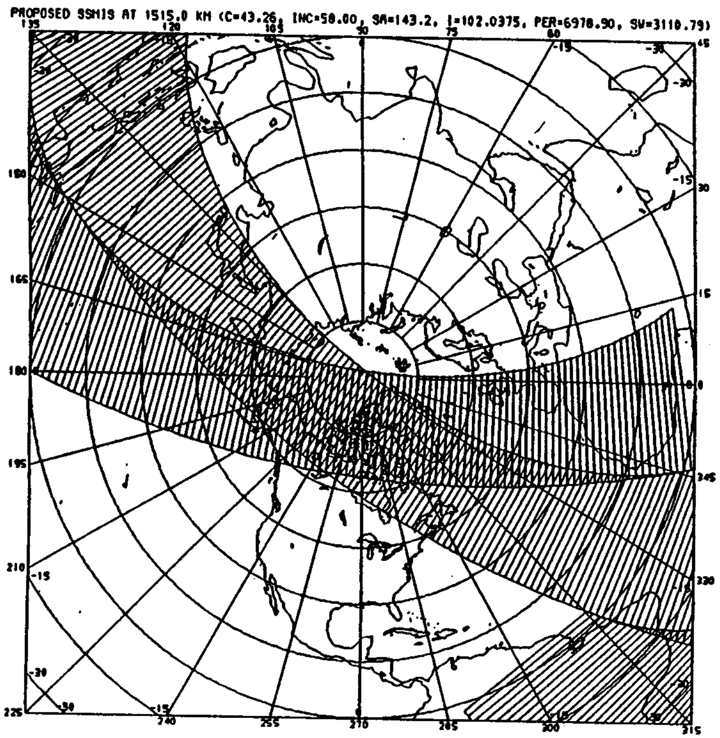


FIGURE 4

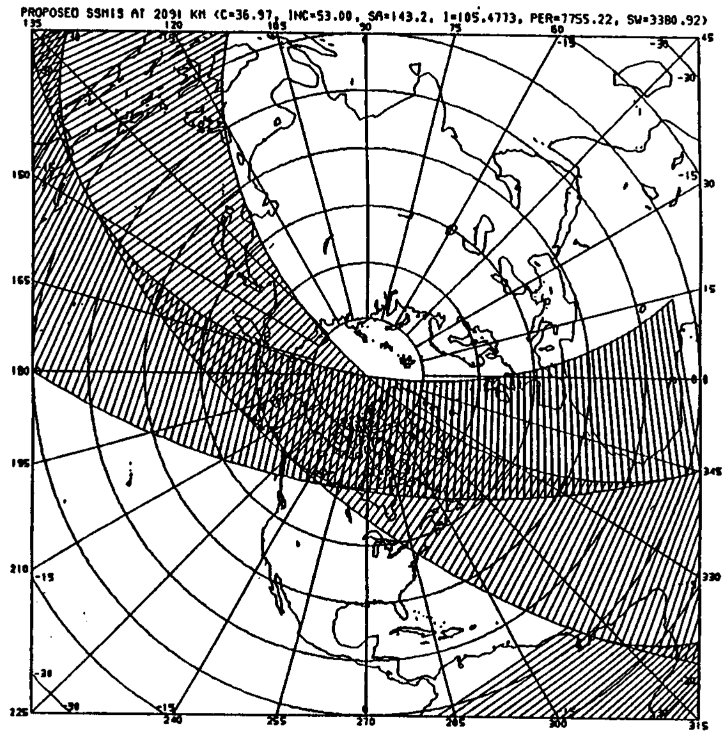


FIGURE 5

SSM/I CHARACTERISTICS

- **CONICAL SCANNING MICROWAVE RADIOMETER**
  - TOTAL POWER RADIOMETER DESIGN
  - 7 CHANNELS: (frequency and polarization)

FREQUENCY (GHz)	POLARIZATION	BANDWIDTH (MHz)
19.35	V & H	240
22.235	V	240
37.00	V & H	900
85.5	V & H	1400

  - ANTENNA:
    - » Offset parabolic reflector, corrugated, broad-band, 7-port horn antenna
    - » 61 x 66 cm reflector
  - CONTINUOUS ROTATION: axis parallel to spacecraft local vertical
    - » 45° nadir angle
    - » $\pm 51.2^{\circ}$ active portion of the cross track scan
    - » 31.6 rev/min, 1.9 sec. period
  - RESOLUTION: 12.5 KM (85 GHz), 50 KM (19 GHz)
  - SWATH WIDTH: 1395 KM
  - DATA RATE: 3276 BITS/SEC

SSM/I CHARACTERISTICS (contd)

- **SAMPLING**
  - » **4.2 msec**
  - » **128 samples/scan at 85 GHz**
  - » **64 samples every other scan at 19, 22, 37 GHz**
- **WEIGHT**
  - » **85 lbs (spinning portion)**
  - » **20 lbs (momentum wheel and electronics)**
- **POWER**
  - » **45 Watts**
- **CALIBRATION**
  - » **Hot/Cold Loads**
  - » **Performed once each 1.9 sec scan**

- THE SSM/I MEASURES THE MICROWAVE EMISSION FROM THE EARTH'S SURFACE AND ATMOSPHERE
- THE RADIANCE SIGNAL IS CONVERTED TO AN EFFECTIVE TEMPERATURE CALLED THE BRIGHTNESS TEMPERATURE, T_B

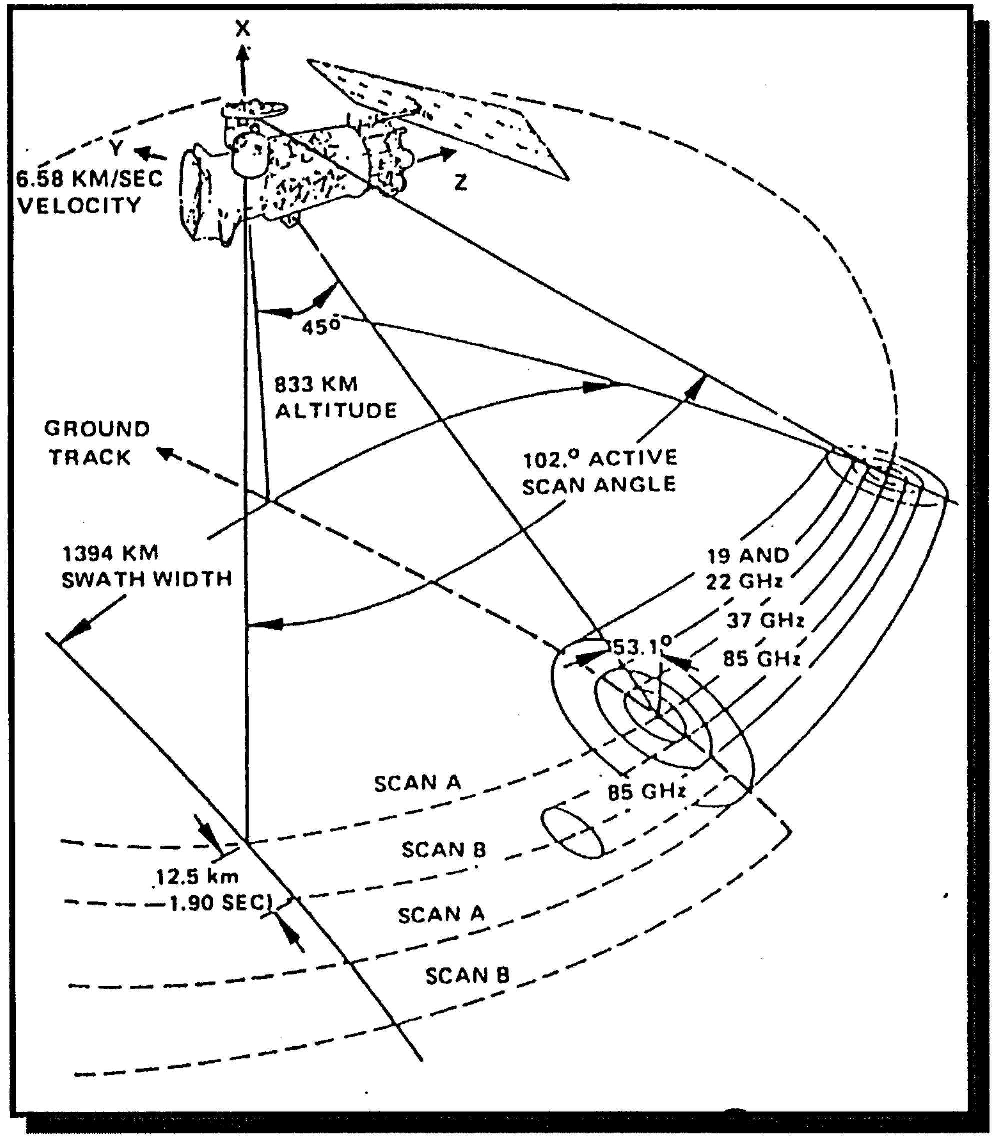
- **SENSITIVITY (F08 PRELAUNCH)**

CHANNEL	ΔT (K)
19V	0.45
19H	0.42
22V	0.73
37V	0.37
37H	0.38
85V	0.69
85H	0.73

NOTE: THE 85 GHz CHANNELS ON THE F08 SSM/I WERE NOT OPERATIONAL DURING THE F08 TILT EXPERIMENT

SSM/I SCAN GEOMETRY

This figure illustrates the scan pattern of the SSM/I as a function of frequency (channel); shown are the ground projections of the antenna 3 dB beam patterns. The SSM/I is a conical scanning radiometer with a constant nadir angle. All of the channels share a common boresight and the scan is from left to right when looking in the aft direction. Also shown is the scan and earth viewing geometry and swath width or coverage. The fact that the spot size of the 85 GHz channel is much smaller than the other channels, combined with the spatial resolution requirements for the geophysical parameters, requires a specialized sampling scheme. The 85 GHz channel is sampled on both the A and B scans whereas the 19, 22 and 37 GHz channels are only sampled on the A scans.



From: DMSP Special Sensor Microwave/Imager Calibration/Validation, DMSP SSM/I CAL/VAL TEAM, Coord. by Jim Hollinger, NRL, Wash. DC (1989).

SUMMARY OF F08 TILT EXPERIMENT

- EXPERIMENT CONDUCTED JUNE 25 THROUGH JULY 13, 1993
- PRIMARY DATA COLLECTION SITE
  - FLEET NUMERICAL OCEANOGRAPHY CENTER (FNOC), MONTEREY, CA
- DATA SETS COLLECTED
  - DMSP SSM/I F08, F10 AND F11
  - RANGE OF PITCH ANGLES AND CORRESPONDING EIA

PITCH ANGLE (DEG)	EARTH INCIDENCE ANGLE (DEG)
0.00	53.24
-2.81	56.99
-5.00	60.13
-8.00	64.74
-10.65	69.12

- NUMBER OF DATASETS (TDR FILE COUNT) COLLECTED AND ARCHIVED TO DATE

	PITCH ANGLE (DEG)					
SATELLITE	0	-2.81	-5.0	-8.0	-10.65	GRAND TOTAL
F8	61	25	42	77	39	
F10	25	19	39	70	41	
F11	35	17	41	77	36	
TOTALS	121	61	122	224	116	644

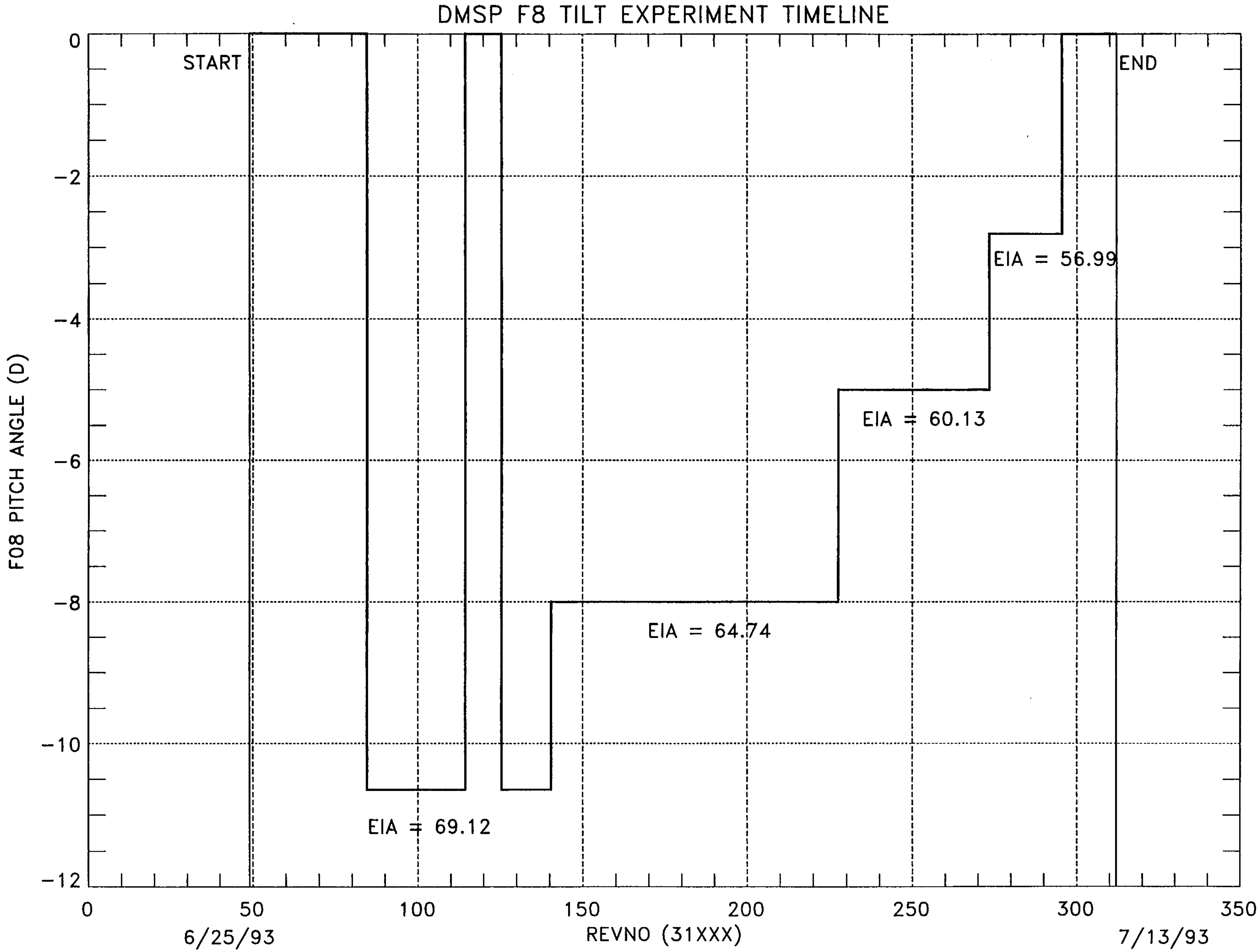
TDR FILE = TEMPERATURE DATA RECORD, CONTAINS ANTENNA TEMPERATURES FOR EACH CHANNEL

- OVER 7 GBYTES OF DATA COLLECTED!

TILT EXPERIMENT TIME LINE

THIS FIGURE ILLUSTRATES THE TIMELINE FOR THE F08TEX. THE EXPERIMENT STARTED 6/25/93 WITH THE COLLECTION OF BASELINE (PITCH = 0°) DATA. ON 6/27/93 THE F08 SPACECRAFT (S/C) WAS PITCHED TO –10.65° (THE MAXIMUM FOR THIS EXPERIMENT). BETWEEN REV. NO. 31115—31125 THE F08 S/C ACCIDENTLY RETURNED TO ZERO PITCH DUE TO MOON INTERFERENCE IN ESA QUADRANT 3. THIS WAS CORRECTED AND THE F08 S/C WAS RETURNED TO –10.65° PITCH BY REV. NO. 31129. FROM THERE, THE F08 S/C PITCH ANGLE WAS SUCCESSIVELY STEPPED DOWN AS SHOWN IN THE FIGURE. ON 7/13/93 THE F08 S/C WAS RETURNED TO ZERO PITCH ANGLE, CONCLUDING THE EXPERIMENT DATA COLLECTION PHASE.

ESA = EARTH SENSOR ASSEMBLY



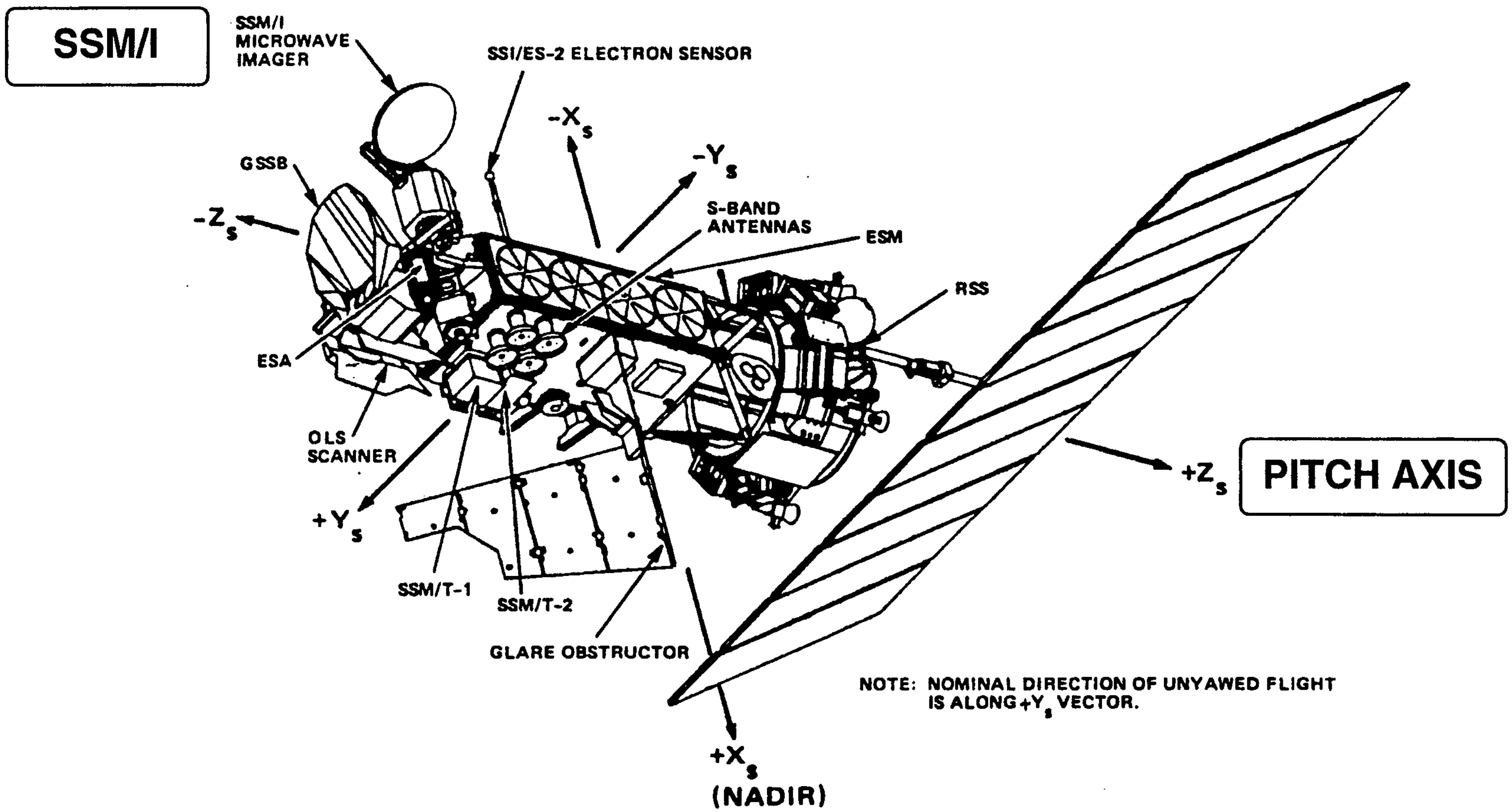
DMSP F8 TILT EXPERIMENT TIMELINE
START
END
EIA = 56.99
EIA = 60.13
EIA = 64.74
EIA = 69.12
F08 PITCH ANGLE (D)
0
-2
-4
-6
-8
-10
-12
0
50
100
150
200
250
300
350
6/25/93
REVNO (31XXX)
7/13/93

DMSP S/C AXES AND EXPERIMENT GEOMETRY

THE NEXT 2 CHARTS ILLUSTRATE THE BODY FIXED AXES AND GEOMETRY PARAMETERS FOR THE TILT EXPERIMENT. THE PITCH AXIS FOR THE DMSP F08 S/C IS THE $+Z_S$ AXIS WHICH RESULTS IN A NEGATIVE PITCH ANGLE GIVING HIGHER VALUES OF EARTH INCIDENCE ANGLE.

THE TILT GEOMETRY DEFINES THE VARIOUS ANGLES USED IN THE TILT EXPERIMENT. NOTE THAT THE SSM/I NADIR OR CONE ANGLE, α, REMAINS UNCHANGED AT 45°. ALSO NOTE THAT AS THE SSM/I SPIN AXIS IS PITCHED AWAY FROM THE LOCAL NADIR DIRECTION, THE SSM/I IS NO LONGER A PURELY CONICAL SCANNING SENSOR, IN THAT THE EIA NOW VARIES WITH SCAN ANGLE.

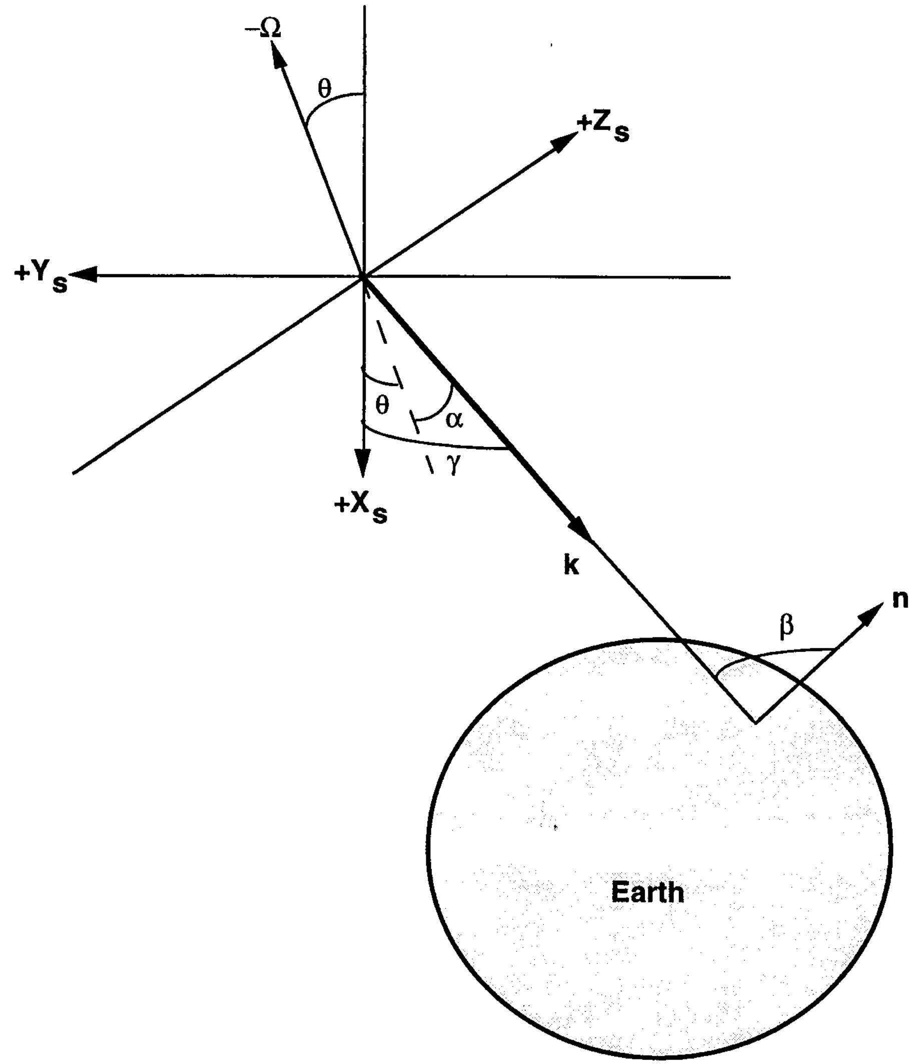
DMSP 5D SPACECRAFT BODY FIXED AXES



NOTE: THIS FIGURE SHOWS THE 5D-3 S/C WITH THE SSM/I. THE GEOMETRY DOES CORRESPOND TO THE 5D-2 S/C WITH THE ACTIVE PORTION OF THE SSM/I SCAN IN THE $-Y_S$ DIRECTION. THE PITCH AXIS IS THE $+Z_S$ AXIS.

TILT GEOMETRY

Pitch Angle	EIA
0.0°	53°
–10.674°	69°
–7.967°	64.5°
–4.999°	60°
–2.875°	57°
0.0°	53°



$X_sY_sZ_s$ – s/c reference coordinate system

α = SSM/I cone angle (45°)

θ = pitch angle, $+Z_s$ is the pitch axis

γ = SSM/I look angle

k = SSM/I look direction

Ω = negative SSM/I spin axis

ϕ = SSM/I scan angle (not shown)

β = earth incidence angle

COINCIDENCE EXAMPLES

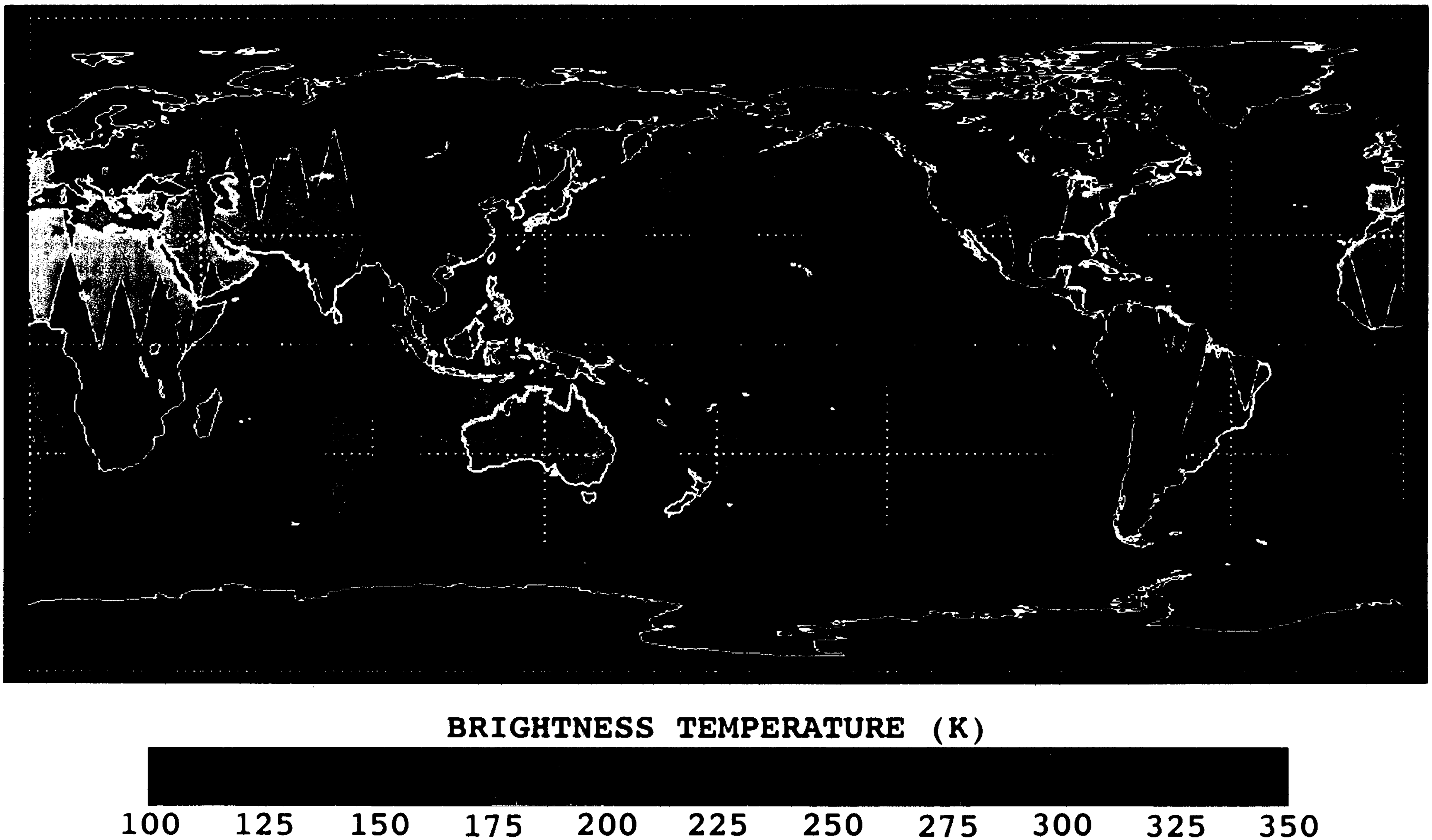
- COINCIDENCE LOCATIONS
  - T_B COMPARISON EXAMPLES
  - GLOBAL MAPS FOR F08 AND F11
    - » BASELINE DATA (PITCH = 0°/ EIA = 53°)
    - » PITCH = –10.65° / EIA = 69°
    - » RESOLUTION = 0.30°

COINCIDENCE COVERAGE

FIGURES 22A,B SHOW THE SENSOR GROUND COVERAGE FOR ONLY THE COINCIDENT DATA. THESE FIGURES ARE FOR THE F08 AND F11 SPACECRAFT DURING THE BASELINE PHASE (ZERO PITCH ANGLE) OF THE EXPERIMENT.

FIGURES 22C,D SHOW THE SENSOR GROUND COVERAGE FOR ONLY THE COINCIDENT DATA. THESE FIGURES ARE FOR THE F08 AND F11 SPACECRAFT DURING THE –10.65° TILT PHASE OF THE EXPERIMENT.

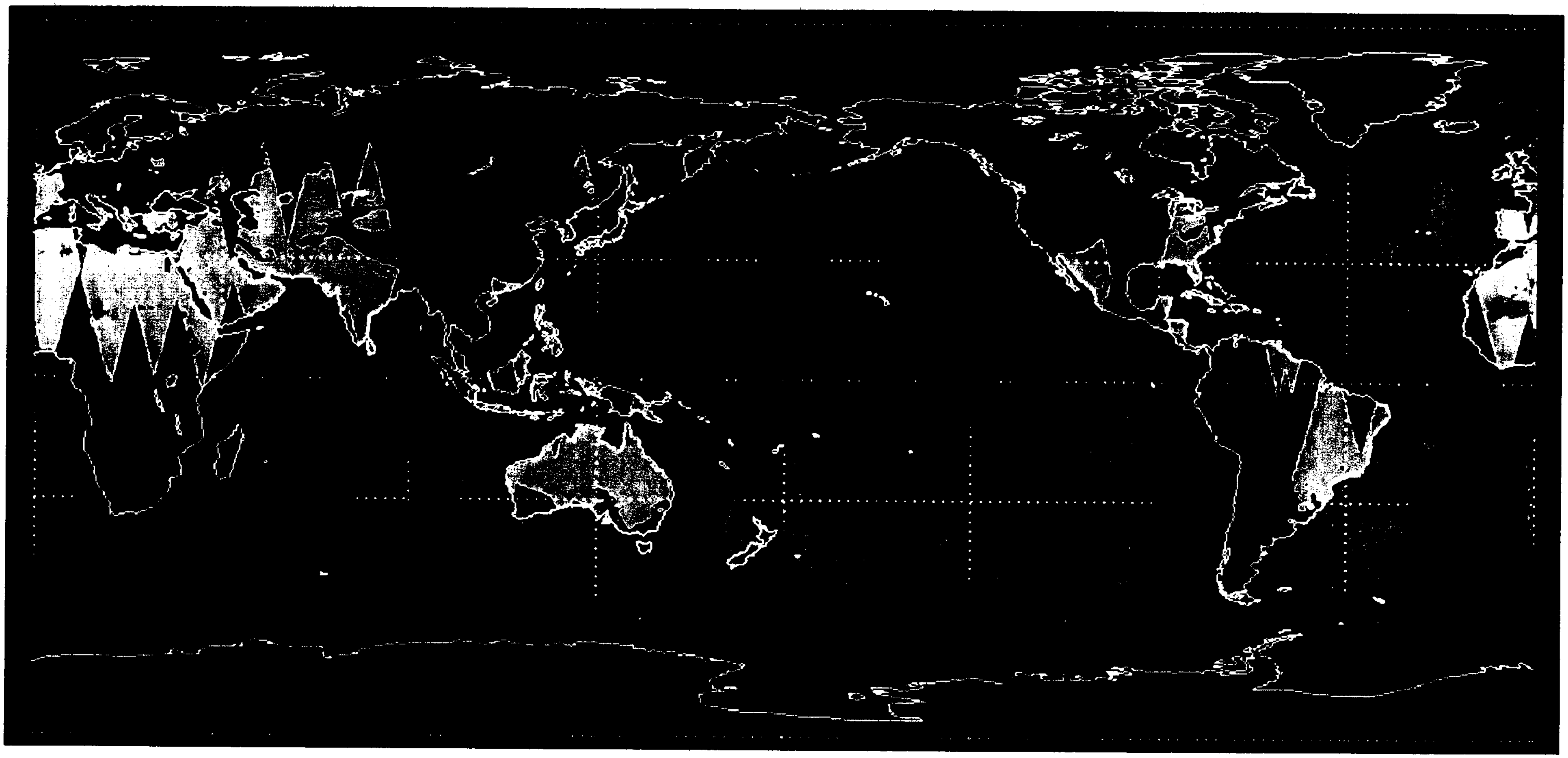
F08 19v BRIGHTNESS TEMPERATURE, 0.0deg TILT
Coincidence Region Only



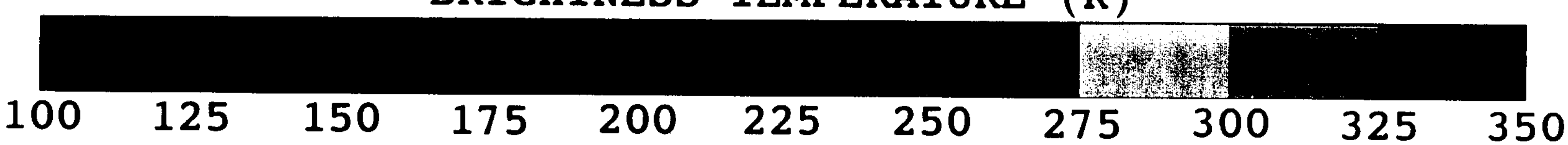
THE AEROSPACE CORPORATION

22-Feb-1995 Samuel Gasster/ Don Rudy

F11 19v BRIGHTNESS TEMPERATURE, 0.0deg TILT
Coincidence Region Only



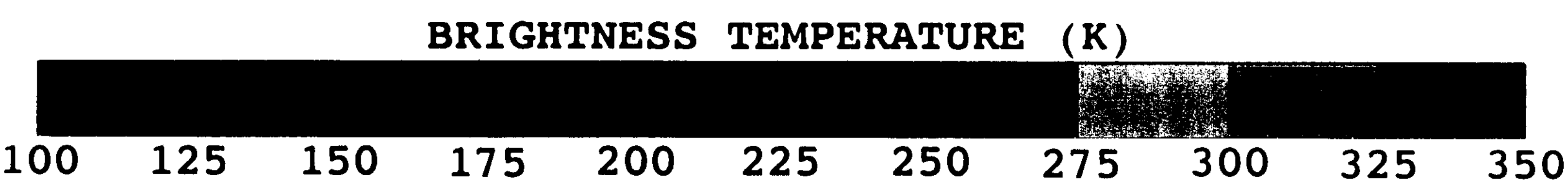
BRIGHTNESS TEMPERATURE (K)



THE AEROSPACE CORPORATION

22-Feb-1995 Samuel Gasster/ Don Rudy

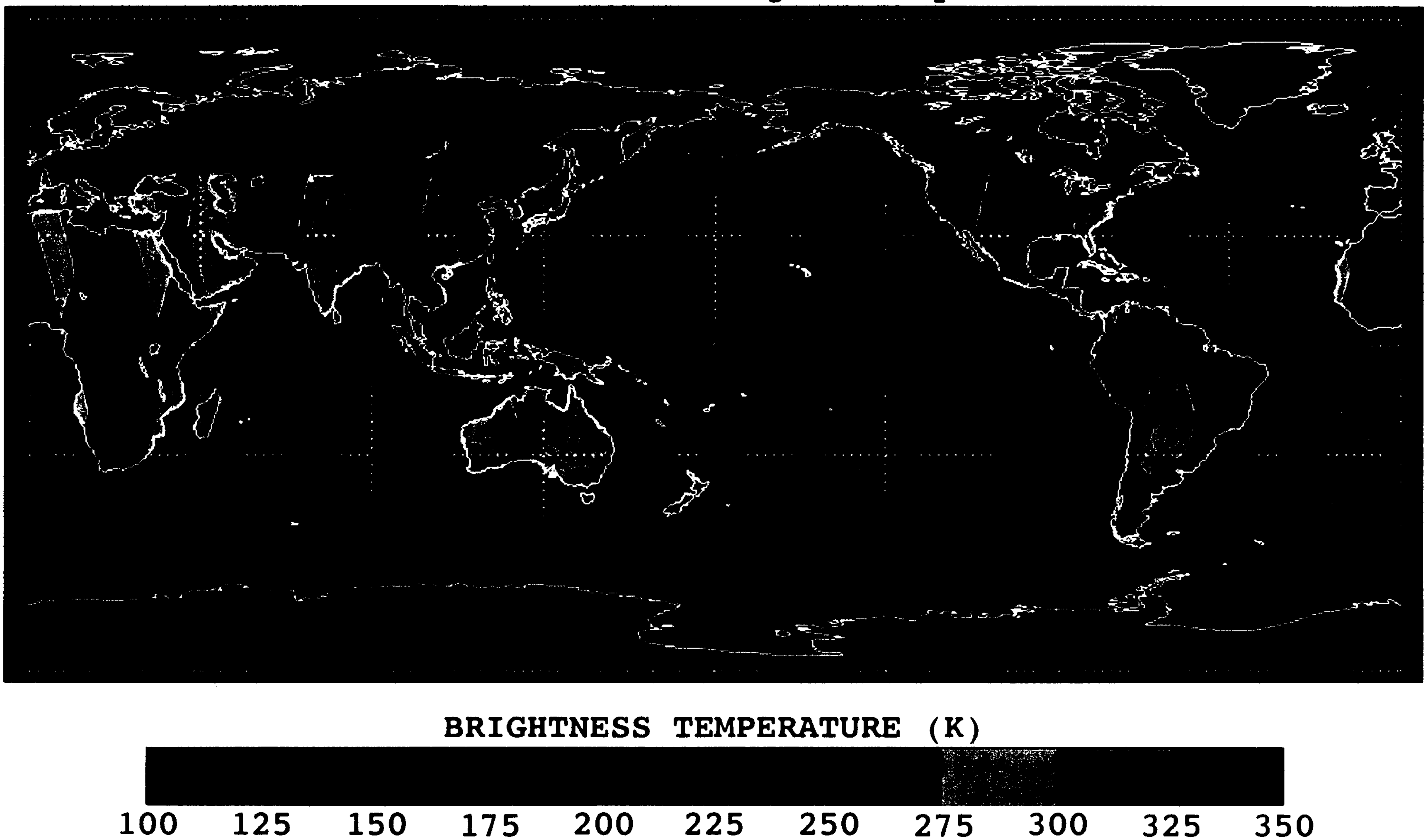
F08 19v BRIGHTNESS TEMPERATURE, -10.67deg TILT
Coincidence Region Only



THE AEROSPACE CORPORATION

22-Feb-1995 Samuel Gasster/ Don Rudy

F11 19v BRIGHTNESS TEMPERATURE, -10.67deg TILT
Coincidence Region Only



THE AEROSPACE CORPORATION

22-Feb-1995 Samuel Gasster/ Don Rudy

ANALYSIS OUTLINE

- **GOAL**
  - OBTAIN PRELIMINARY RESULTS ON HIGHEST EIA DATA COLLECTED USING ONLY F08 AND F11 SSM/I DATA
  - EXAMINE VARIATION OF F08 BRIGHTNESS TEMPERATURES WITH EDRs GENERATED USING F11 DATA
- **SOFTWARE AND ALGORITHM DEVELOPMENT REQUIRED**
  - QUICK LOOK ANALYSIS AT FNOC DURING THE EXPERIMENT
  - READ DEF FORMATTED DATA FILES (TDR, SDR, EDR AND QDR)
  - READ/DISPLAY AND ANALYZE HOT/COLD LOAD DATA
  - ALGORITHM TO CONVERT TDR TO SDR (ANTENNA PATTERN CORRECTIONS)
  - GEOLOCATION SOFTWARE
  - COINCIDENCE EXTRACTION
  - *REGRID* DATA TO UNIFORMLY SPACED SAMPLES (NEAREST NEIGHBOR SELECTION)
  - WILD POINT EDITING : SPIKES AND ZEROS (DATA DROPOUTS)
  - REFORMAT DATA AND SAVE TO UNFORMATTED FILES FOR EASE OF ACCESS
  - MISCELLANEOUS DATA VISUALIZATION AND MANIPULATION TOOLS
- **DATA QUALITY**
  - WITH SUCH A LARGE DATASET DATA QUALITY ASSESSMENT IS VERY TIME CONSUMING AND AN ON-GOING PROCESS

TDR = TEMPERATURE DATA RECORD — ANTENNA TEMPERATURES

SDR = SENSOR DATA RECORD — BRIGHTNESS TEMPERATURES

EDR = ENVIRONMENTAL DATA RECORD — RETRIEVED GEOPHYSICAL PARAMETERS

QDR = QUALITY DATA RECORD — DATA QUALITY FLAGS

DEF = DATA EXCHANGE FORMAT

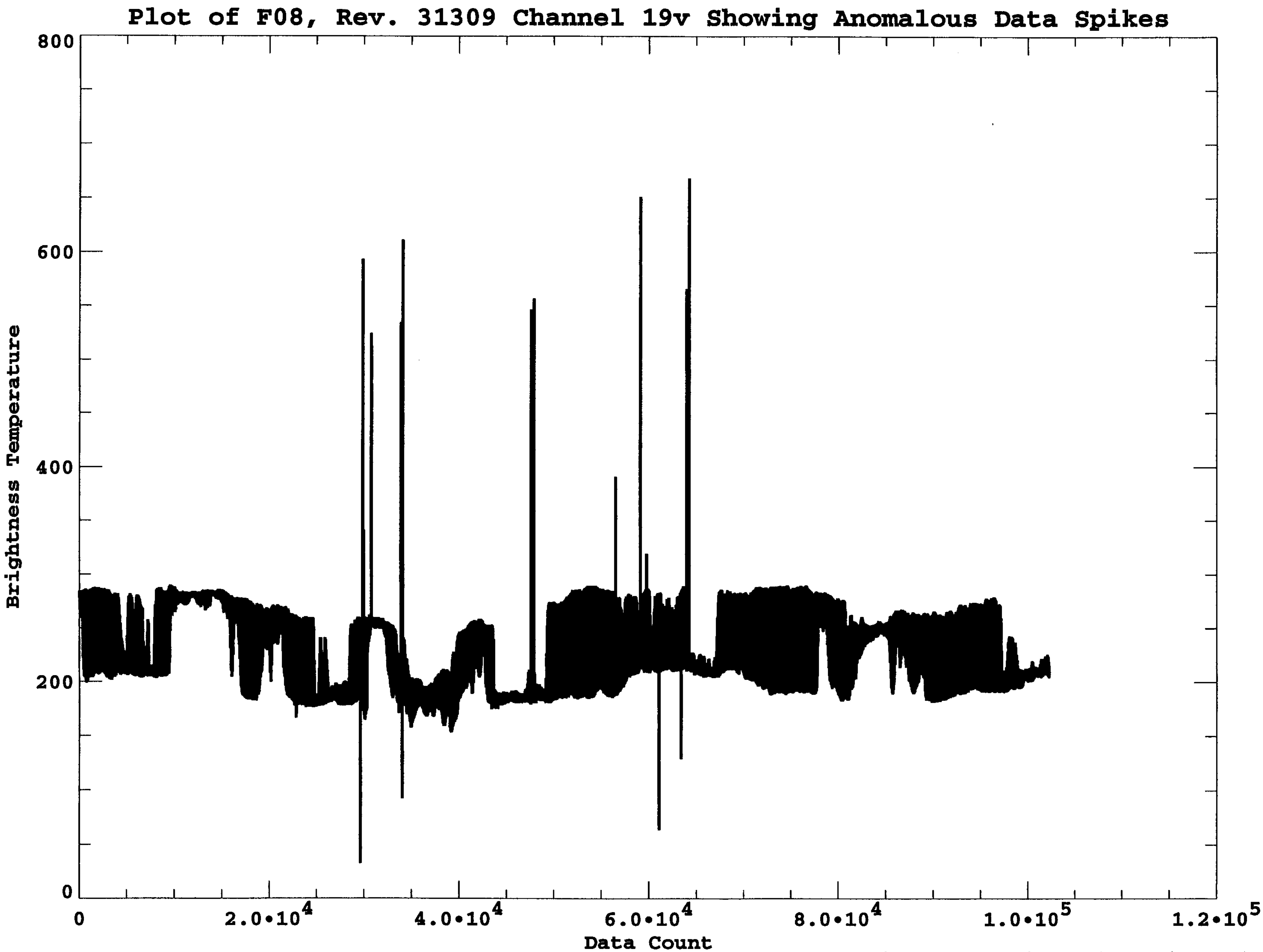
ANALYSIS OUTLINE (contd)

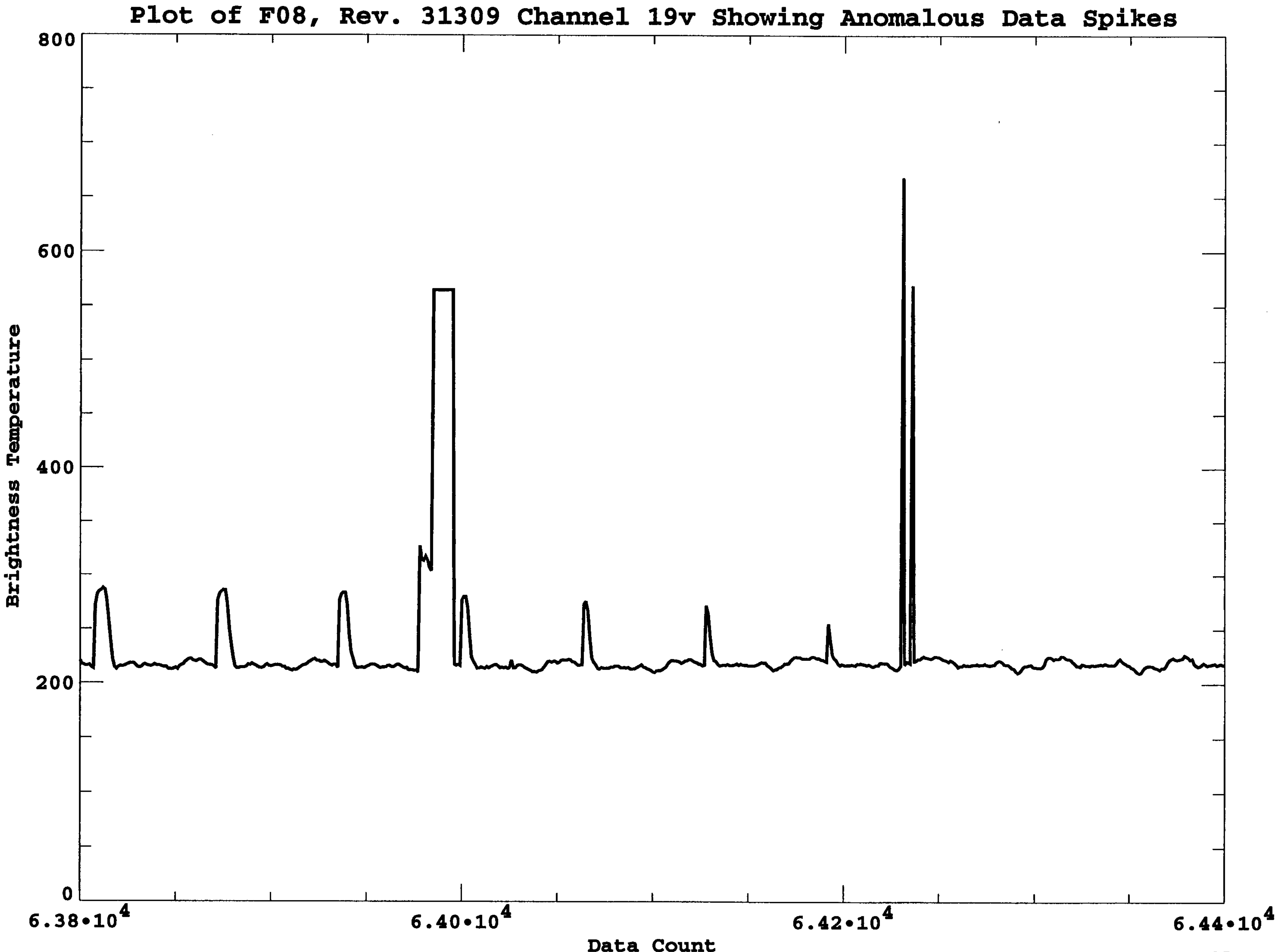
- DATA QUALITY ASSESSMENT
  - CHECK EACH TDR FILE FOR ERRORS IN FILE FORMAT — FOUND LOTS!
  - EXAMINE HOT/COLD LOAD DATA
  - SEARCH TDR FILES FOR WILD POINTS (SPIKES OR DATA DROPOUTS)
- GENERATE BRIGHTNESS TEMPERATURES (SDRs)
  - START WITH FNOC GENERATED TDR FILES (ANTENNA TEMPERATURES)
  - READ EPHEMERIS DATA AND GEOLOCATE
  - COMPUTE F08TEX ANTENNA PATTERN CORRECTION
  - SAVE SDR DATA IN AEROSPACE SDR FORMAT
- EXTRACT F08/F11 COINCIDENCES
  - 30MIN/30KM CONSTRAINT
  - OVER OCEAN ONLY
- GENERATE F11 EDRs
- STATISTICAL ANALYSIS OF BRIGHTNESS TEMPERATURES AND EDRs
- EXAMINED BASELINE DATA OVER NRL CAL/VAL REGIONS
  - VALIDATES STABILITY OF SSM/I

WILD POINT EXAMPLES

THE FOLLOWING 2 CHARTS ILLUSTRATE EXAMPLES OF DATA WILD POINTS ENCOUNTERED IN THE DMSP SSM/I DATA. SHOWN ARE SPIKES IN THE 19V CHANNEL OF F08, FOR REV NO. 31309. THESE SPIKES OCCUR IN THE TDR FILES (ANTENNA TEMPERATURE DATA) AND AS SUCH WILL ALSO SHOW UP IN THE SDR (BRIGHTNESS TEMPERATURE) DATA.

THE FIRST FIGURE SHOWS NUMEROUS SPIKES IN THIS PARTICULAR DATASET, AND THE SECOND FIGURE SHOWS AN EXPANDED VIEW OF A SUBSET OF THIS DATA. IN ADDITION TO SINGLE PIXEL SPIKES WE FIND MULTIPLE SPIKES WHICH CAN CORRUPT A COMPLETE SCAN. SINGLE PIXEL SPIKES CAN BE EASILY AND ACCURATELY HANDLED WITH A 3 OR 5 POINT MEDIAN FILTER. IF A PARTICULAR SCAN HAS A LARGE NUMBER OF SPIKES WE IGNORE THE WHOLE SCAN.


Plot of F08, Rev. 31309 Channel 19v Showing Anomalous Data Spikes
Brightness Temperature
800
600
400
200
0
0
2.0•10^4
4.0•10^4
6.0•10^4
8.0•10^4
1.0•10^5
1.2•10^5
Data Count


Plot of F08, Rev. 31309 Channel 19v Showing Anomalous Data Spikes
800
600
400
200
0
Brightness Temperature
6.38•10^4
6.40•10^4
6.42•10^4
6.44•10^4
Data Count

TDR DATA FILE
DESCRIPTION: DEF FORMAT

SATELLITE ID, ORBIT NUMBER, DATES AND TIMES

;Product Origin: FNOC
;Product Id.   : SMITDR
;Product date: 15/ 6/93   22: 6
;Data block   0 has structure :
; SCID REV# BJLD BHR BMN BSEC EJLD EHR EMN ESEC AJLD AHR AMN ASEC LSI
;It has   1 sections.

EPHEMERIS DATA, OFFSETS, GAINS

;Data block   1 has structure :
; CNTR BSTM EMV LAT LON ALT HLD3 HLD2 HLD1 CR2 CR1 TR   TPC AGC3 AGC2
; AGC1 S19V O19V S19H O19H S22V O22V S37V O37V S37H O37H S85V O85V S85H O85H
;It has   1 sections.

CHANNEL HOT AND COLD LOAD DATA, GAINS

;Data block   2 has structure :
; CNTR C1   C1   C1   C1   C1   C2   C2   C2   C2   C2   C3   C3   C3   C3
; C3   C4   C4   C4   C4   C4   C5   C5   C5   C5   C5   C6   C6   C6   C6
; C6   C7   C7   C7   C7   C7   H1   H1   H1   H1   H1   H2   H2   H2   H2
; H2   H3   H3   H3   H3   H3   H4   H4   H4   H4   H4   H5   H5   H5   H5
; H5   H6   H6   H6   H6   H6   H7   H7   H7   H7   H7   AGC3 AGC2 AGC1 C6
; C6   C6   C6   C6   C7   C7   C7   C7   C7   H6   H6   H6   H6   H6   H7
; H7   H7   H7   H7
;It has   1 sections.

GEOLOCATED ANTENNA TEMPERAURE DATA AND SURFACE TYPE

;Data block   3 has structure :
; CNTR LAT LON T19V T19H T22V T37V T37H T85V T85H STYP PONO LAT LON T85V
; T85H STYP PONO LAT LON T85V T85H STYP PONO LAT LON T85V T85H STYP PONO
;It has   64 sections.

TDR→SDR CONVERSION

THE CONVERSION OF TDR DATA (ANTENNA TEMPERATURE DATA) TO SDR DATA (BRIGHTNESS TEMPERATURE DATA) IS AN IMPORTANT PART OF THE DATA ANALYSIS PREPROCESSING FOR THE F08 TILT EXPERIMENT. TO OBTAIN SDR DATA THE SSM/I TDR DATA IS ANTENNA PATTERN CORRECTED (APC) AS PART OF THE OPERATIONAL PROCESSING AT FNOC AND AFGWC. DUE TO THE NON-ZERO PITCH ANGLES USED IN THE TILT EXPERIMENT AND THE VARIATION OF THE SSM/I FOOTPRINT AT THE HIGH EIA, WE PROPOSED USING A MODIFIED VERSION OF THE APC NORMALLY APPLIED TO THE SSM/I DATA. WORKING WITH THE NAVAL RESEARCH LABORATORY A PROPOSED APC PROCEDURE WAS DEVELOPED AND BRIEFED TO THE DMSP SPO AND CONTRACTORS. THE AGREED UPON ALGORITHM WAS APPLIED, USING THE APPROPRIATE PARAMETERS, TO THE F08, F10 AND F11 SSM/I DATA. THIS WAS DONE FOR THE SAKE OF CONSISTENCY. THIS SECTION SUMMARIZES THE BASIS FOR THE PROPOSED ALGORITHM AND DESCRIBES THE FINAL ALGORITHM EMPLOYED.

TDR→SDR CONVERSION
BACKGROUND

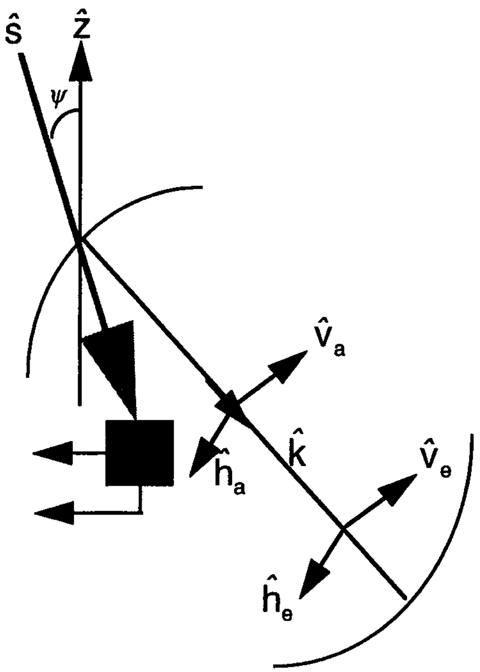
- **PRIMARY ISSUE IS THE ANTENNA PATTERN CORRECTION (APC) ALGORITHM**
- **BASELINE CASES (F08, F10, F11)**
  - **USE APC AS IMPLEMENTED AT FNOC**
  - **EXAMPLE**

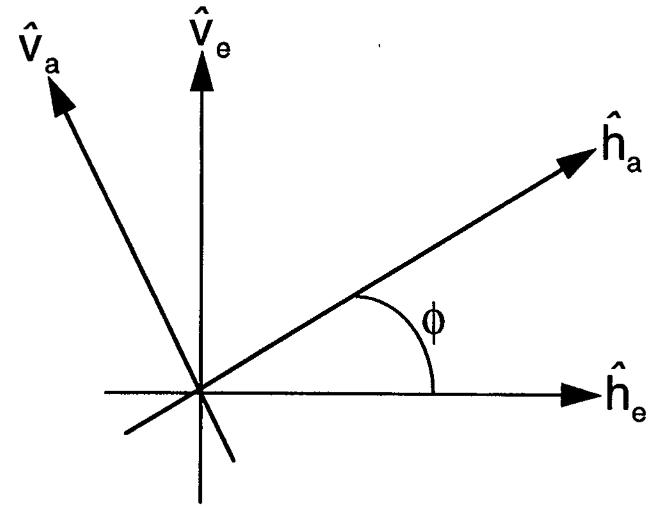
$$T^{k}_{B,V}(f) = c_{V,0}T^{k}_{A,V}(f) + c_{H,0}T^{k}_{A,H}(f) + c_{V,-1}T^{k-1}_{A,V}(f) + c_{V,+1}T^{k+1}_{A,V}(f)$$

$$c_{q,j} = \text{ APC Coefficients}$$

  - **SIMILAR EXPRESSION FOR** $T^{K}_{B,H}$
  - **REQUIRES MODEL FOR 22H CHANNEL** $T^{K}_{A,H}(22) = aT^{K}_{A,H}(19) + b$
  - **a AND b DEPEND ON PITCH ANGLE**
- **TILTED F08 APC**
  - **POLARIZATION ROTATION**
  - **RECOMMENDED APC**
- **AGREE ON APC ALGORITHM**
- **EVERYONE DEVELOP THEIR OWN IMPLEMENTATION**
- **APPLY TO TEST DATASET AND COMPARE**
  - **AEROSPACE WILL IDENTIFY TEST DATASETS, ONE FOR EACH PITCH ANGLE**
  - **EVERYONE COMPUTE SDR FILES FOR EACH TEST TDR CASE**
  - **AEROSPACE WILL PERFORM COMPARISON AND REPORT RESULTS**
  - **ITERATE UNTIL WE ALL AGREE**

RATIONALE FOR APC





$$\begin{bmatrix} E_{V_A} \\ E_{H_A} \end{bmatrix} = \begin{pmatrix} \alpha & \beta \\ \gamma & \delta \end{pmatrix} \begin{pmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{pmatrix} \begin{bmatrix} E_{V_e} \\ E_{H_e} \end{bmatrix}$$

$$T_{V_A} = \text{const}\left\langle E_{V_A} E_{V_A}^* \right\rangle = \begin{pmatrix} |\alpha|^2 \cos^2\phi + |\beta|^2 \sin^2\phi + \sin 2\phi \Re\{\alpha\beta^*\} \\ |\alpha|^2 \sin^2\phi + |\beta|^2 \cos^2\phi - \sin 2\phi \Re\{\alpha\beta^*\} \\ \left(|\alpha|^2 - |\beta|^2\right) \sin 2\phi + \cos 2\phi \Re\{\alpha\beta^*\} \\ -2\Im\{\alpha\beta^*\} \end{pmatrix}^T \begin{bmatrix} T_{V_e} \\ T_{H_e} \\ T_{r_e} \\ T_{i_e} \end{bmatrix}$$

$$T_{re} + iT_{ie} = \text{const.}\left\langle E_{V_e} E_{H_e}^* \right\rangle$$

RECOMMENDED F08 APC

$$\begin{bmatrix} T_{V_A} \\ T_{H_A} \end{bmatrix} = \begin{pmatrix} |\alpha|^2 \cos^2\phi + |\beta|^2 \sin^2\phi & |\alpha|^2 \sin^2\phi + |\beta|^2 \cos^2\phi \\ |\gamma|^2 \cos^2\phi + |\delta|^2 \sin^2\phi & |\gamma|^2 \sin^2\phi + |\delta|^2 \cos^2\phi \end{pmatrix} \begin{bmatrix} T_{V_e} \\ T_{H_e} \end{bmatrix}$$

$$\begin{bmatrix} T_{V_A} \\ T_{H_A} \end{bmatrix} = A \begin{bmatrix} T_{V_e} \\ T_{H_e} \end{bmatrix}$$

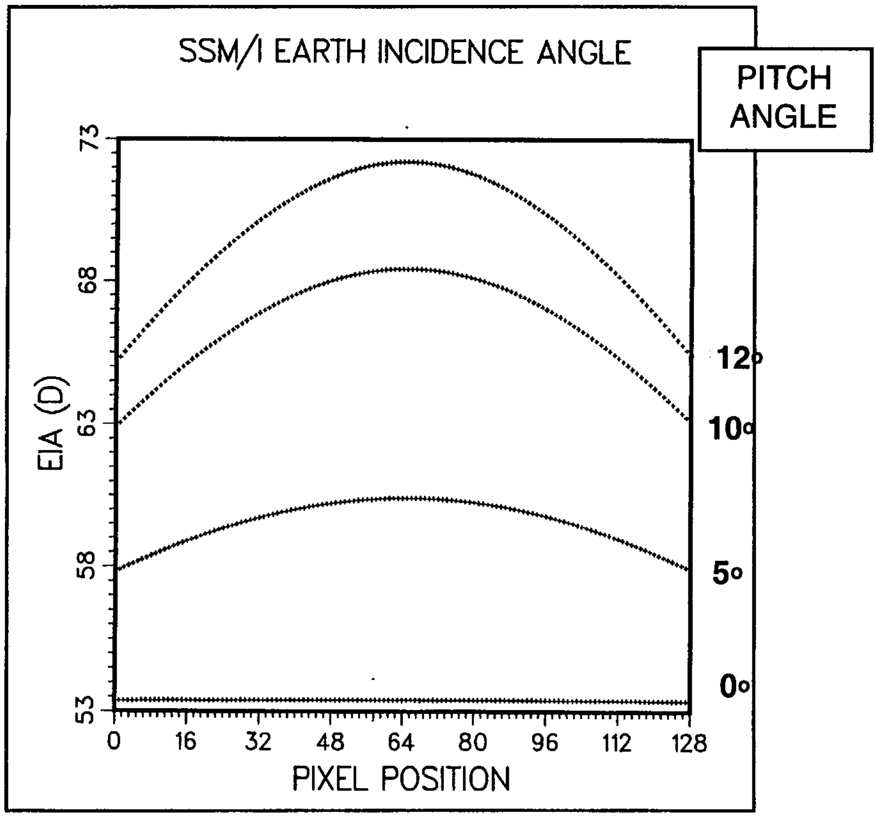
$$\begin{bmatrix} T_{V_e} \\ T_{H_e} \end{bmatrix} = A^{-1} \begin{bmatrix} T_{V_A} \\ T_{H_A} \end{bmatrix}$$

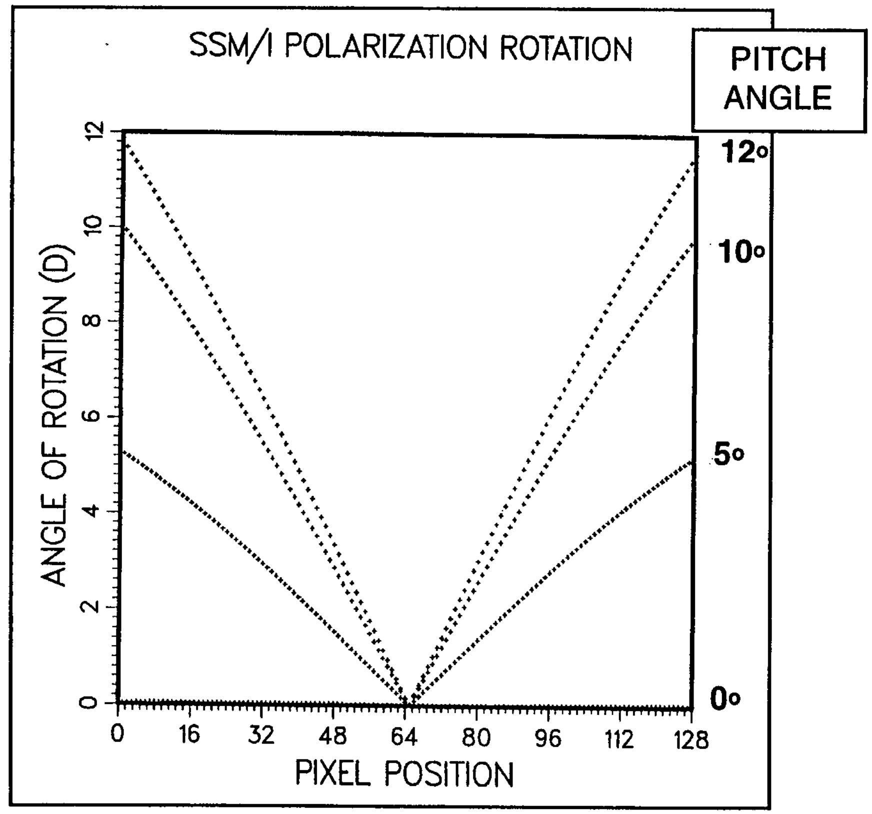
$$T^{K}_{A,H}(22) = aT^{K}_{A,H}(19) + b$$

a and b depend on ψ

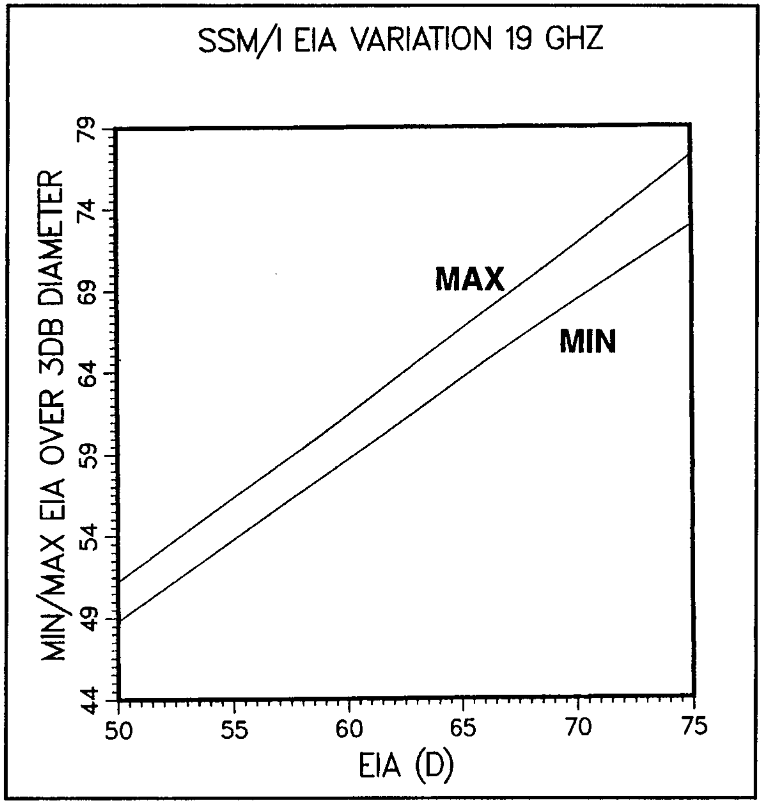
CHANNEL	$\|\alpha\|^2$	$\|\beta\|^2$	$\|\gamma\|^2$	$\|\delta\|^2$
19 GHz	0.9644	0.00460	0.00400	0.9650
22 GHz	0.9636	0.0104	–	–
37 GHz	0.9646	0.0214	0.0258	0.9602

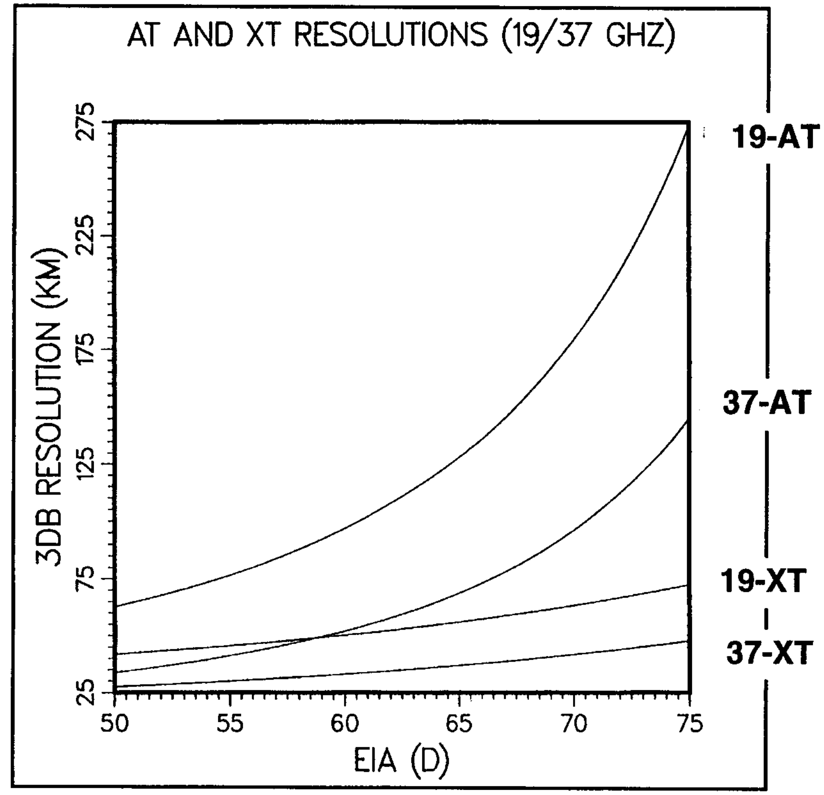
VARIATION OF EIA AND POLARIZATION ROTATION ANGLE WITH SCAN POSITION





VARIATION OF 3 dB RESOLUTION WITH EIA





AT = ALONG-TRACK

XT = CROSS-TRACK

TDR→SDR CONVERSION
APC ALGORITHM

- **F08TEX APC ALGORITHM**
  - C_0 and C_X ARE COEFFICIENTS THAT DEPEND ON SSM/I FREQUENCY AND POLARIZATION
  - T_A ANTENNA TEMPERATURE
  - SIMILAR EXPRESSION FOR THE H POLARIZED CHANNELS
  - THIS FORM APPLIES TO BOTH TILTED AND UNTILTED DATA, HOWEVER FOR THE TILTED DATA THE COEFFICIENTS VARY WITH THE POLARIZATION ROTATION ANGLE Φ_P

$$T_B(f,V) = C_0 T_A(f,V) + C_X T_A(f,H)$$

- **F08 TILTED APC**
  - VALID FOR 19V,H AND 37V,H
  - INVERT MATRIX M — M PROVIDED BY GENE POE, NRL
  - FOR 22V CHANNEL WE MUST USE SIMULATED 22H — MODEL FOR 22H KINDLY PROVIDED BY ALEX STOGRYN, AES
  - THE e_i COEFFICIENTS ARE FUNCTIONS OF THE AES MODEL PARAMETERS, PITCH(EIA) ANGLE AND SSM/I PARAMETERS (M)

$$T_A = M(\Phi_P) T_B$$

$$T_B(22,V) = e_0 T_A(22,V) + e_1 T_A(19,H) + e_2 T_A(19,V) + e_3$$

AEROSPACE
SUPPORT TO CONTRACTORS

- **AEROSPACE PROVIDED F08TEX DATA TO CONTRACTORS**
  - DISTRIBUTION INCLUDES 8MM DATA TAPES AND DOCUMENTATION
  - PROVIDED CODE TO READ DEF FORMATTED DATA FILES (CODE ORIGINATED AT FNOC — RESEARCH GRADE)
  - Q&A SUPPORT
- **NRL AND AEROSPACE DEVELOPED TDR TO SDR CONVERSION ALGORITHM SPECIFICALLY FOR TILT EXPERIMENT**
  - HELD TIM TO DISCUSS APC AND RELATED ISSUES
  - AES VOLUNTEERED THEIR ALGORITHM FOR COMPUTING 22H CHANNEL — REQUIRED FOR APC ALGORITHM
  - PROVIDED ALGORITHM TO CONTRACTORS
  - IDENTIFIED TEST TDR DATASETS
  - AGREED TO VALIDATE CONTRACTORS TDR TO SDR CONVERSION USING TEST TDR DATASET
    - » RECEIVED DATA FROM LMSC, FINISHED VALIDATION
    - » RECEIVED DATA FROM AES ON 3/3/95 — VALIDATION IN PROGRESS

GEOLOCATION

- TDR DATA WAS GEOLOCATED AT FNOC USING THEIR STANDARD PROCESSING SOFTWARE MODIFIED FOR THE F08TEX, HOWEVER...
  - FULL F08TEX APC REQUIRES POLARIZATION ROTATION ANGLE WHICH IS COMPUTED AS PART OF GEOLOCATION ALGORITHM
  - ALSO REQUIRES COMPUTATION OF EIA
- AEROSPACE HAS IMPLEMENTED FULL SSM/I GEOLOCATION ALGORITHM DEVELOPED AT NRL
  - NRL SUPPLIED FORTRAN CODE WHICH WE CONVERTED TO IDL CODE
  - CODE COMPUTES FOR EACH PIXEL:
    - » LAT, LON, EIA & POLR
- COMPARED AEROSPACE GEOLOCATION WITH RESULTS FROM BOTH FNOC AND NRL — RESULTS EXCELLENT
- EXAMPLE OF GEOLOCATED F08TEX DATA
  - F08 AT -10.65° PITCH
  - F11
  - RESOLUTION = 0.30°
- REFERENCES
  - SSM/I CAL/VAL REPORT (NRL)
  - GENE POE, IEEE GSRS JOURNAL ARTICLE

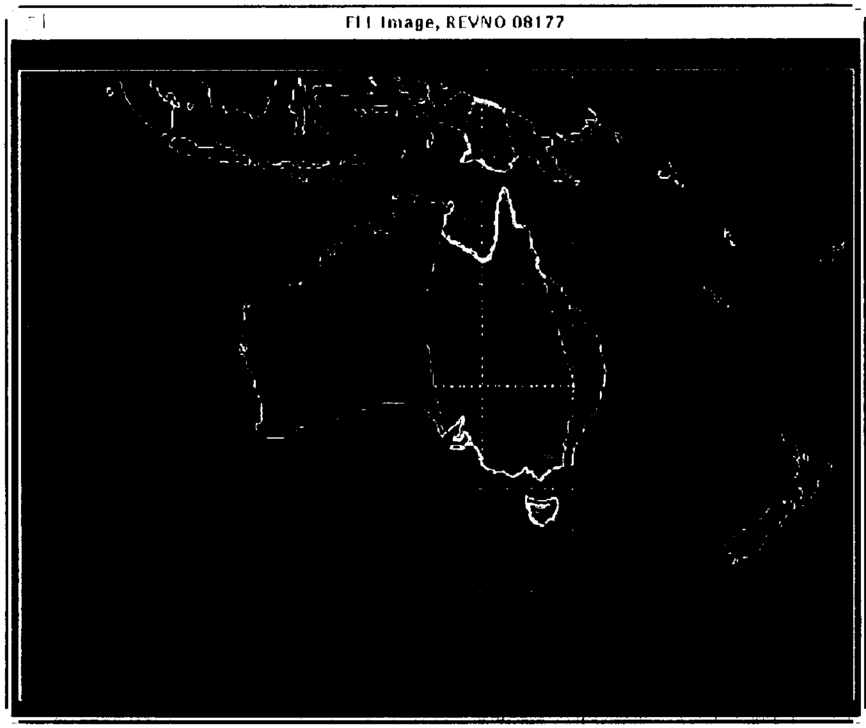
GEOLOCATION EXAMPLE

AS A QUALITATIVE TEST OF THE GEOLOCATION OF THE F08 DATA AT NON-ZERO PITCH ANGLES, WE COMPARED THE F08 DATA AT THE –10.65° PITCH WITH COINCIDENT F11 DATA (ZERO PITCH). THIS CHART SHOWS A COMPARISON BETWEEN 2 COINCIDENT F08 AND F11 PASSES OVER AUSTRALIA. THIS COMPARISON IS USEFUL IN THAT THERE ARE FAIRLY SHARP LAND/OCEAN BOUNDARIES WHICH CAN BE USED TO ASCERTAIN, IN A QUALITATIVE MANNER, HOW WELL THE F08 IS GEOLOCATED RELATIVE TO THE F11 DATA.

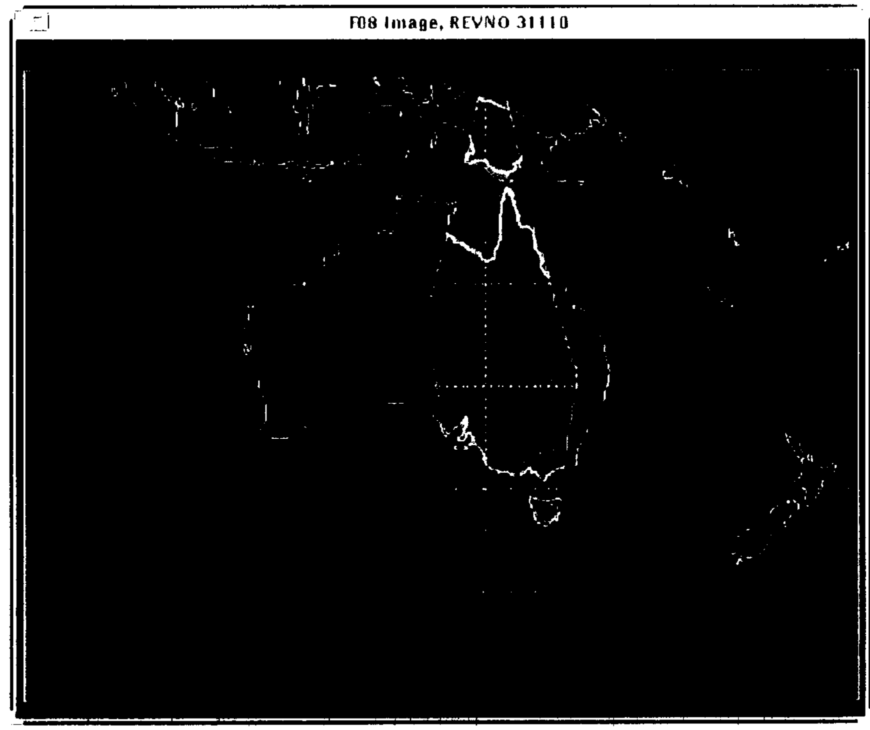
THE 2 DATASETS WERE REMAPPED TO A UNIFORMLY SAMPLED GRID WITH 0.3° RESOLUTION AND THEN MAPPED TO A CYLINDRICAL MERCATOR PROJECTION. THE COASTLINE DATABASE USED IS PROBABLY ACCURATE TO NO BETTER THAN 25 KM (THE GEOLOCATION ALGORITHM SHOULD BE ACCURATE TO 7 KM OR BETTER). IN ADDITION, RECALL THAT THE F08 FOOTPRINT, FOR THE HIGH EIA CASE, IS ABOUT 3 TIMES LARGER IN THE ALONG TRACK DIRECTION THAN FOR THE BASELINE CASE. GIVEN THIS, THE RESULTING COMPARISON OF THE GEOGRAPHICAL FEATURES IN EACH IMAGE IS QUITE GOOD. WE HAVE ALSO MADE A QUANTITATIVE COMPARISON WITH THE GEOLOCATION PERFORMED AT FNOC (AND STORED IN THE TDR FILES), AND HAVE OBTAINED EXCELLENT AGREEMENT.

GEOLOCATION EXAMPLE
COMPARISON OF F11 (NO PITCH) WITH F08 (PITCH = −10.65D)

F11-08177



F08-31110



BRIGHTNESS TEMPERATURE (K)

EDR GENERATION

THE ANALYSIS OF THE F08 TILT EXPERIMENT DATA REQUIRES THE COMPARISON OF THE MEASURED BRIGHTNESS TEMPERATURES FROM THE F08 SSM/I WITH THE ENVIRONMENTAL DATA RECORDS (EDR) COMPUTED FROM THE F11 SSM/I DATA. THE EDRs OF INTEREST FOR THE F08 TILT EXPERIMENT ARE THE OCEAN SURFACE WIND SPEED, TOTAL INTEGRATED WATER VAPOR, CLOUD LIQUID WATER, RAIN FLAG AND RAIN RATE. WE USE THE DMSP F08 CAL/VAL ALGORITHMS USING ONLY THE 19, 22 AND 37 GHz CHANNELS FROM THE F11 SATELLITE.

REFERENCE

DMSP SPECIAL SENSOR MICROWAVE/IMAGER CALIBRATION/VALIDATION, VOL. I AND II, JIM HOLLINGER, ED. (1989).

EDR GENERATION

- **CONVERSION OF BRIGHTNESS TEMPERATURES TO ENVIRONMENTAL PARAMETERS**
- **DMSP CAL/VAL ALGORITHMS USED IN ALL CASES**
- **SURFACE TYPE DETERMINED FROM STATIC DATA BASE AND DYNAMIC COMPUTATION (FROM T_B)**
- **EXAMPLE**
  - **OCEAN SURFACE WIND SPEED (SW)**

```
SWmin =  0.0                ;min/max ocean surface wind values (m/sec)
SWmax = 25.3
QSW = 0.1                   ;SW quantization level
;
;          define algorithm coefficients
;
           A0 =  147.90
           A1 =  1.0969
           A2 = -0.4555
           A3 = -1.7600
           A4 =  0.7860
;
SW(ocean)= A0 + A1*Tb19V(ocean) + A2*Tb22V(ocean) +  A3*Tb37V(ocean)+ A4*Tb37H(ocean)
```

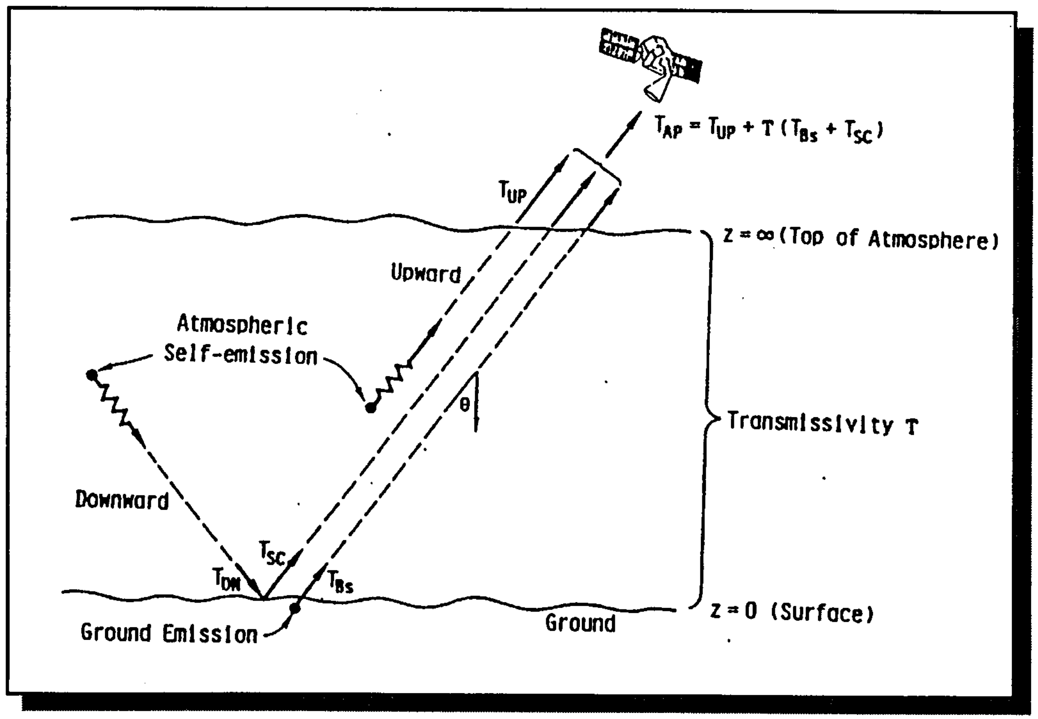
```
;The algorithm is only applied to ocean pixels
;and the accuracy is determined by the value of RF:
;
;          RF          Acc (m/sec)
;          --          -----------
;          0           <2
;          1           2-5
;          2           5-10
;          3           >10

RF = RAIN FLAG
```

MODEL PREDICTIONS

THIS SECTION SUMMARIZES THE INITIAL MODEL CALCULATIONS PERFORMED AS A GUIDE IN OUR INTERPRETATION OF THE F08 TILT EXPERIMENT DATA. THE MODEL CALCULATIONS ARE BASED ON A MICROWAVE RADIATIVE TRANSFER MODEL FOR COMPUTING THE TOTAL BRIGHTNESS TEMPERATURE INCIDENT ON THE SPACEBORNE RADIOMETER (SSM/I IN THIS CASE). THE MODELS USED ARE DESCRIBED AND ARE BASED PRIMARILY ON SEVERAL SEMI-EMPIRICAL MODELS REPORTED IN THE LITERATURE. WHILE THESE MODELS MAY NOT CAPTURE ALL THE MINUTE DETAILS OF A FULL SCATTERING MODEL CALCULATION, THEY SERVE TO INDICATE THE GENERAL TRENDS WE WOULD EXPECT TO OBSERVE IN THE F08 TILT EXPERIMENT DATA. WE PLAN TO RUN MORE MODEL CALCULATIONS AS PART OF OUR FOLLOW-ON ANALYSIS, ATTEMPTING TO MORE CLOSELY MATCH THE CONDITIONS FOR A PARTICULAR DATA COLLECTION.

MODEL PREDICTIONS

- PERFORMED MW RADIATIVE TRANSFER MODEL CALCULATIONS TO PREDICT T_B OVER OCEAN
- MODEL DESCRIPTION
  - PROVIDED BY GENE POE, NRL
  - FORTRAN CODE WHICH READS THE FOLLOWING PARAMETERS
    - » FREQUENCY (GHz)
    - » EIA(degrees)
    - » WIND SPEED (m/sec)
    - » SEA SURFACE TEMPERATURE (C)
    - » SALINITY (ppt)
    - » ATMOSPHERIC MODELS



MICROWAVE RADIATIVE TRANSFER MODEL
SUMMARY

- **RADIATIVE TRANSFER MODEL TO PREDICT TOTAL MW BRIGHTNESS TEMPERATURE INCIDENT ON SENSOR**
- **TOTAL T_B**

$$T_B(f,q,\theta) = L(f,\theta)T_{BS}(f,q,\theta) + T_{ATM}(f,\theta)$$

TOTAL BRIGHTNESS AT FREQUENCY f, POLARIZATION q = V or H, AND DIRECTION θ.

ATMOSPHERIC ATTENUATION

TOTAL SURFACE BRIGHTNESS

ATMOSPHERIC PATH EMISSION

- **SURFACE BRIGHTNESS IS COMPOSED OF 2 COMPONENTS**
  - **EMISSION FROM FOAM-FREE AND FOAM-COVERED WATER SURFACE, POSSIBLY ROUGHENED BY WIND WAVES AND SWELL**
  - **REFLECTED SKY EMISSION (DOWNWELLING ATMOSPHERIC RADIANCE) FROM FOAM-FREE AND FOAM-COVERED WATER SURFACE, POSSIBLY ROUGHENED BY WIND WAVES AND SWELL**

MICROWAVE RADIATIVE TRANSFER MODEL SUMMARY

- **ATMOSPHERIC ATTENUATION**
  - γ = TOTAL ATMOSPHERIC EXTINCTION COEFFICIENT DUE TO DRY AIR, H_2O, O_2 AND CLOUDS
  - H = TOP OF THE ATMOSPHERE

$$L(f,\theta) = exp\left[-sec\,\theta\int_0^H \gamma(f,z)dz\right]$$

- **ATMOSPHERIC EMISSION TERM**

$$T_{ATM}(f,\theta,Z) = sec\,\theta\int_0^Z \gamma(f,z')T_{AIR}(z')\,exp\left[-sec\,\theta\int_{z'}^Z \gamma(f,z'')dz''\right]dz'$$

- **SKY EMISSION**

$$T_{SKY}(f,\theta,Z) = LT_{COS} + sec\,\theta\int_0^\infty \gamma(f,z')T_{AIR}(z')\,exp\left[-sec\,\theta\int_0^Z \gamma(f,z'')dz''\right]dz'$$

T_{COS} = COSMIC BACKGROUND RADIATION

MICROWAVE RADIATIVE TRANSFER MODEL SUMMARY

- **SURFACE BRIGHTNESS TERMS**

$$T_{BS}(f,q,\theta) = \begin{array}{l} \left[(1-F)\varepsilon(f,q,\theta)+F\varepsilon_F(f,q,\theta)\right]T_{SEA} \\ +\left[(1-F)\left\{1-\varepsilon(f,q,\theta)\right\}+F\left\{1-\varepsilon_F(f,q,\theta)\right\}\right]T_{SKY} \end{array}$$

F = fraction of surface covered by foam

ε = emissivity from a foam-free ocean surface , with a wind speed dependent roughness

ε_F = emissivity from a foam covered ocean surface , with a wind speed dependent roughness

BOTH ε and ε_F DEPEND ON FREQUENCY, LOCAL INCIDENCE ANGLE, WIND SPEED, ..., AND OTHER GEOPHYSICAL PARAMETERS

SPECIFIED BY SEMI-EMPIRICAL MODELS

MICROWAVE RADIATIVE TRANSFER MODEL
SUMMARY

- **SAMPLE MODEL ATMOSPHERIC PROFILES**

- **MODEL PREDICTIONS**
  - USE THE SSM/I FREQUENCIES AND POLARIZATIONS
  - T_B vs EIA AT WIND SPEED = 0, 10, 20 m/sec
  - T_B vs WIND SPEED, EIA = 53° AND 69°
  - $T_{B,V}$–$T_{B,H}$ (POLARIZATION DIFFERENCE) vs WIND SPEED, EIA = 53° AND 69°
  - SCATTER PLOT OF T_B(69°) vs T_B(53°)

- **NOTE:**
  - EIA = 53°
    - » $T_{B,V}$ INCREASES WITH WIND SPEED
    - » $T_{B,H}$ INCREASES WITH WIND SPEED
  - EIA = 69°
    - » $T_{B,V}$ DECREASES WITH WIND SPEED
    - » $T_{B,H}$ INCREASES WITH WIND SPEED
  - RELATIVE DEPENDENCE OF T_B(V,H) ON EIA, WIND SPEED AND WATER VAPOR

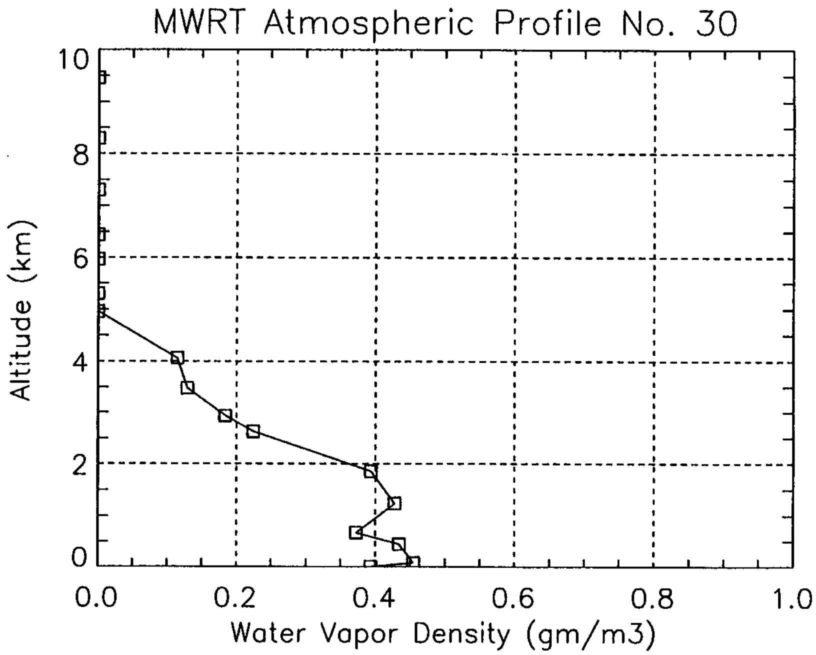
MODEL ATMOSPHERIC PROFILES

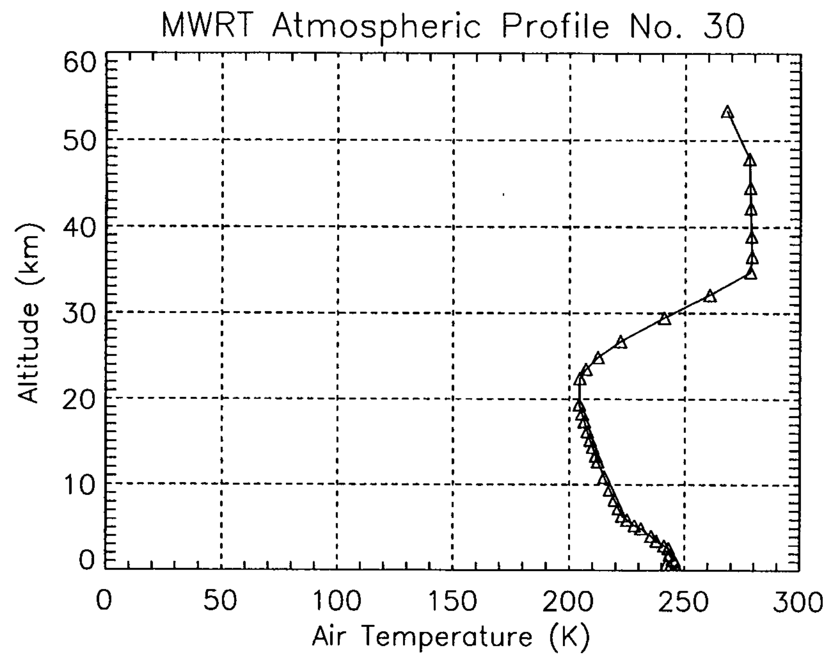
THE FOLLOWING 2 CHARTS ILLUSTRATE THE MODEL ATMOSPHERIC PROFILES USED IN THE MICROWAVE RADIATIVE TRANSFER MODEL CALCULATIONS. THE PROFILES ARE FOR:

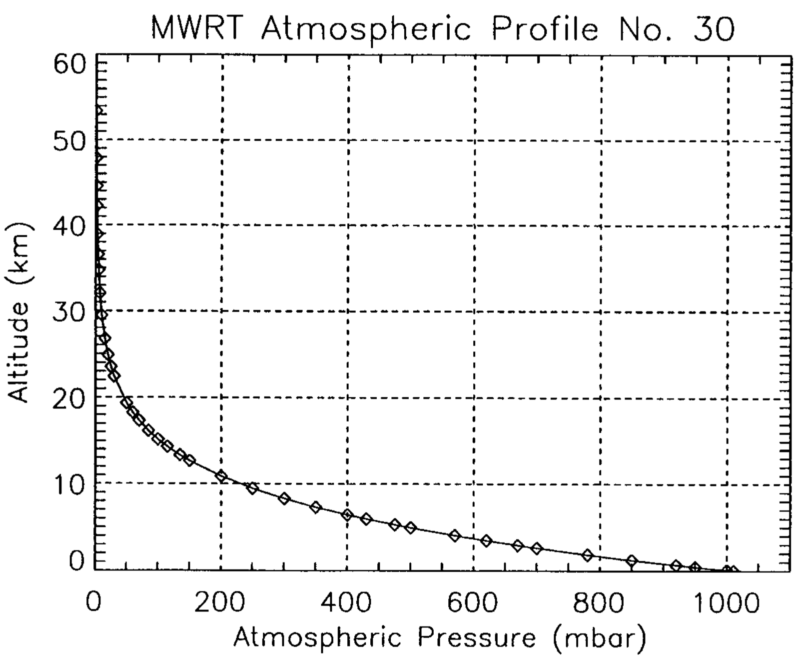
- $\rho_{H2O}(z)$ =WATER VAPOR DENSITY (gm/m^3)
- $T_{AIR}(z)$ = AIR TEMPERATURE (K)
- P(z) = ATMOSPHERIC PRESSURE (mbar)

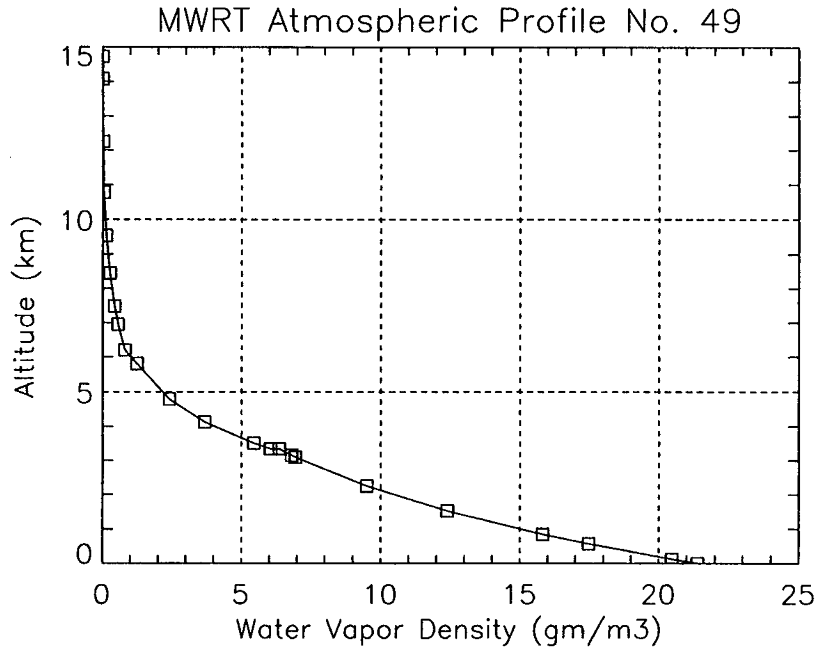
PROFILE NO. 30 CORRESPONDS TO A TOTAL INTEGRATED WATER VAPOR OF 1.2 kg/m^2

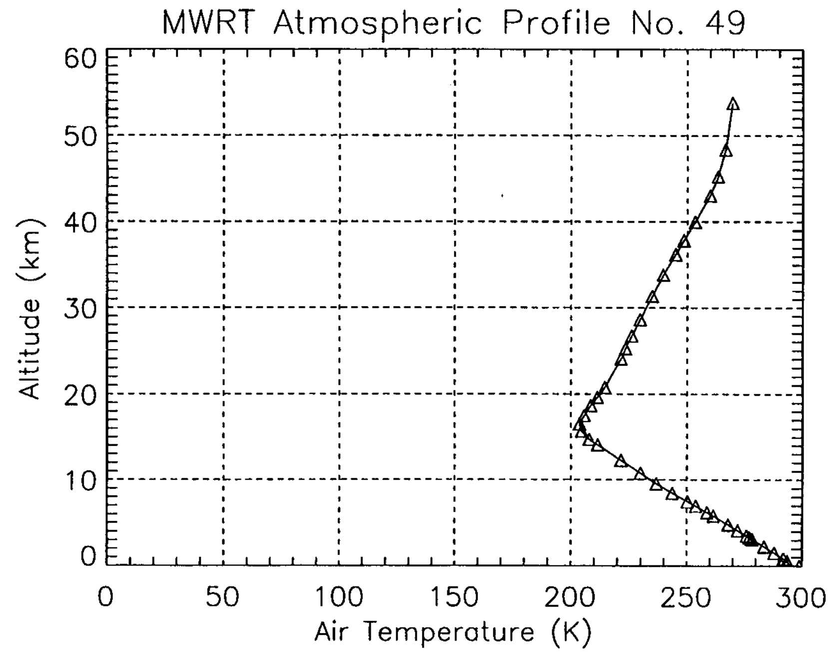
PROFILE NO. 49 CORRESPONDS TO A TOTAL INTEGRATED WATER VAPOR OF 51 kg/m^2

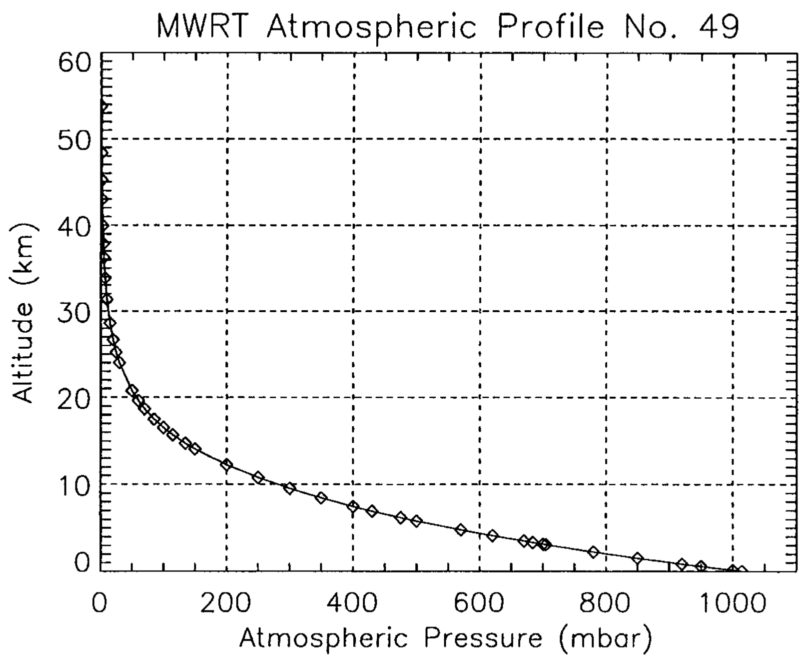

MWRT Atmospheric Profile No. 30
Altitude (km)
Water Vapor Density (gm/m3)
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10


MWRT Atmospheric Profile No. 30
Altitude (km)
Air Temperature (K)
0
50
100
150
200
250
300
0
10
20
30
40
50
60


MWRT Atmospheric Profile No. 30
Altitude (km)
Atmospheric Pressure (mbar)
0
200
400
600
800
1000
0
10
20
30
40
50
60


MWRT Atmospheric Profile No. 49
Altitude (km)
Water Vapor Density (gm/m3)
0
5
10
15
20
25


MWRT Atmospheric Profile No. 49
Altitude (km)
Air Temperature (K)
0
10
20
30
40
50
60
100
150
200
250
300


MWRT Atmospheric Profile No. 49
Altitude (km)
Atmospheric Pressure (mbar)
0
10
20
30
40
50
60
200
400
600
800
1000

MW RADIATIVE TRANSFER CALCULATIONS

THE FOLLOWING CHARTS SHOW RESULTS OF THE VARIOUS MW RADIATIVE TRANSFER MODEL CALCULATIONS. THE FOLLOWING PARAMETERS ARE COMMON TO ALL THREE PLOTS:

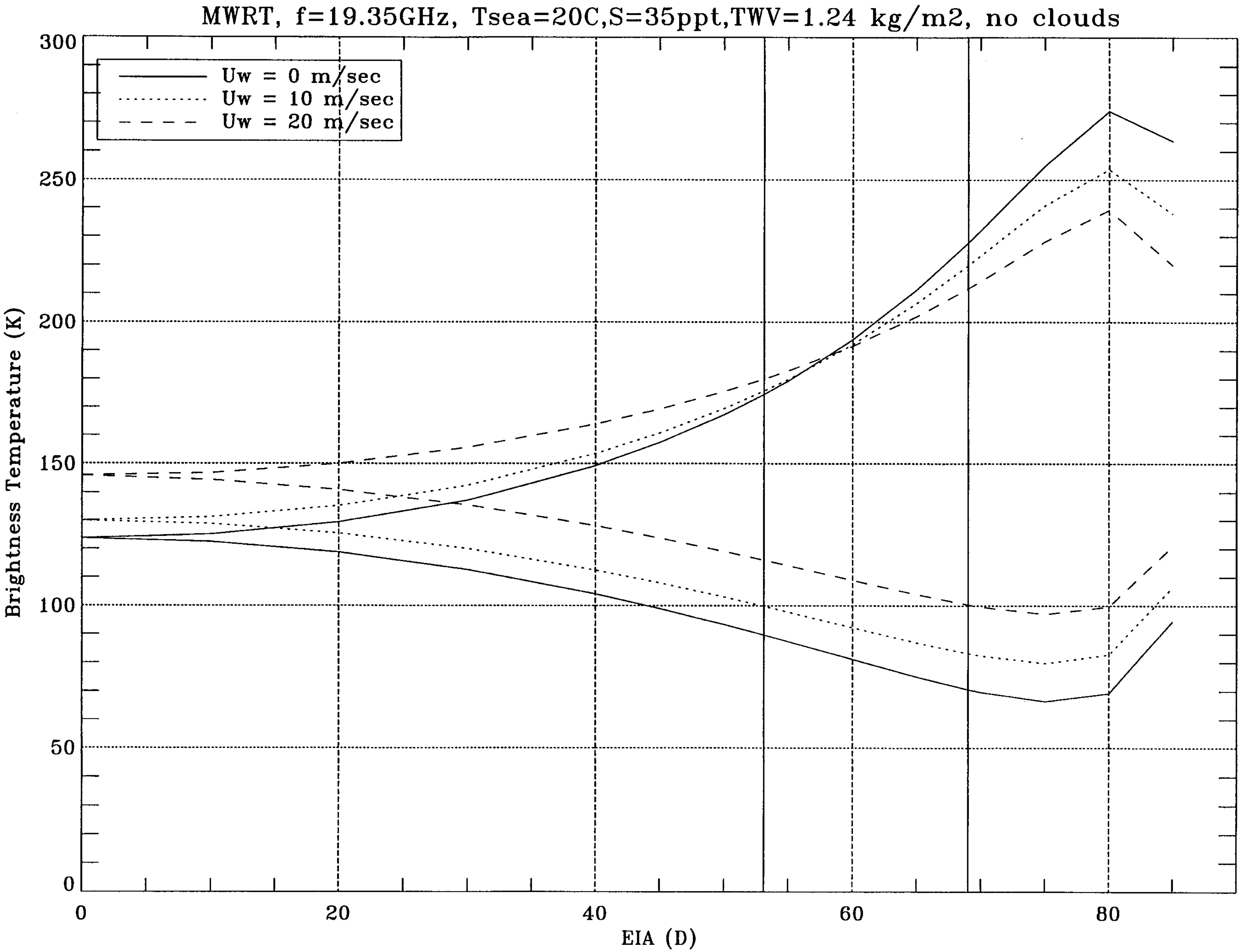
$$F = 19.35 \text{ GHz}$$

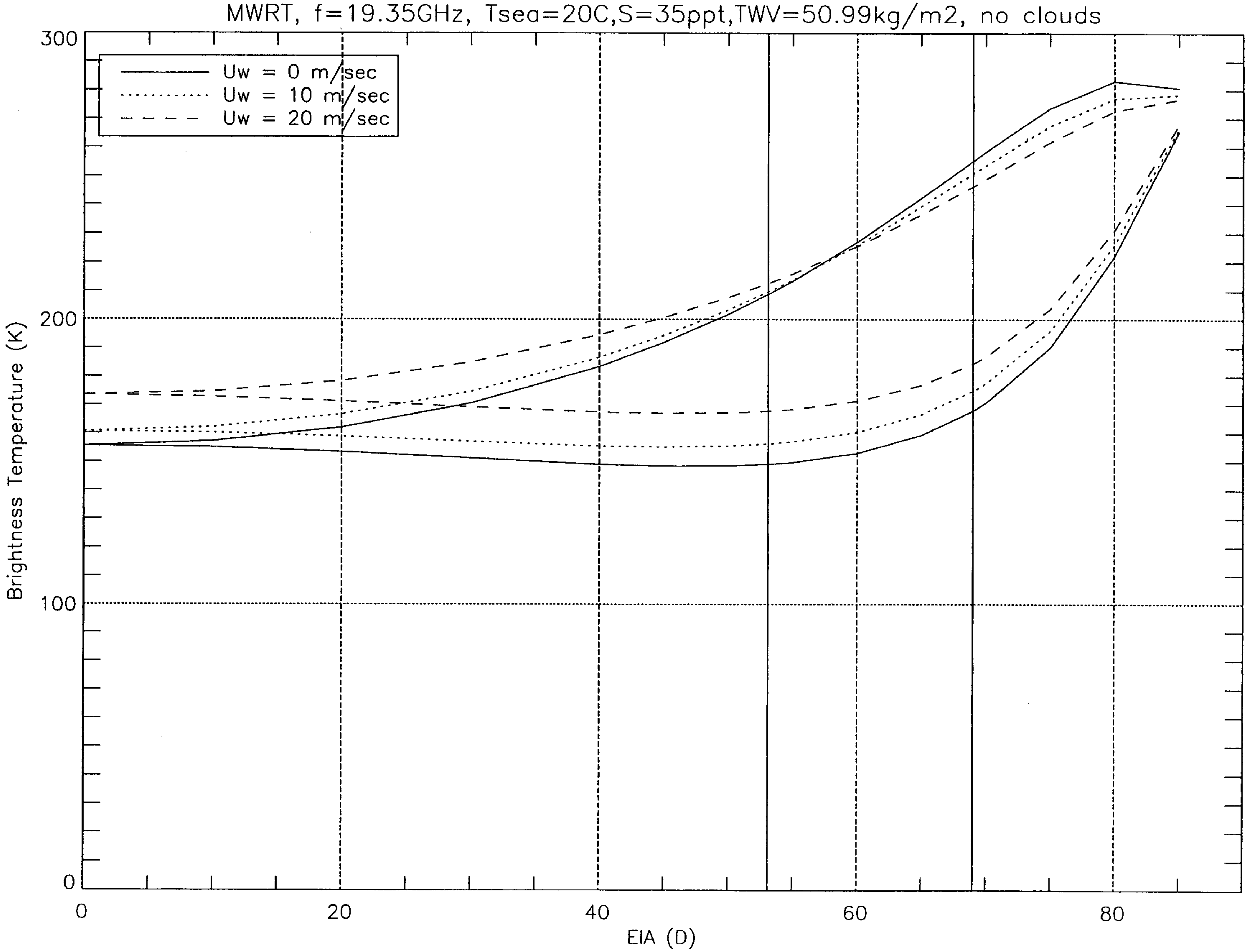
$$T_{SEA} = 20 \text{ C}$$

$$\text{SALINITY} = 35 \text{ PPT}$$

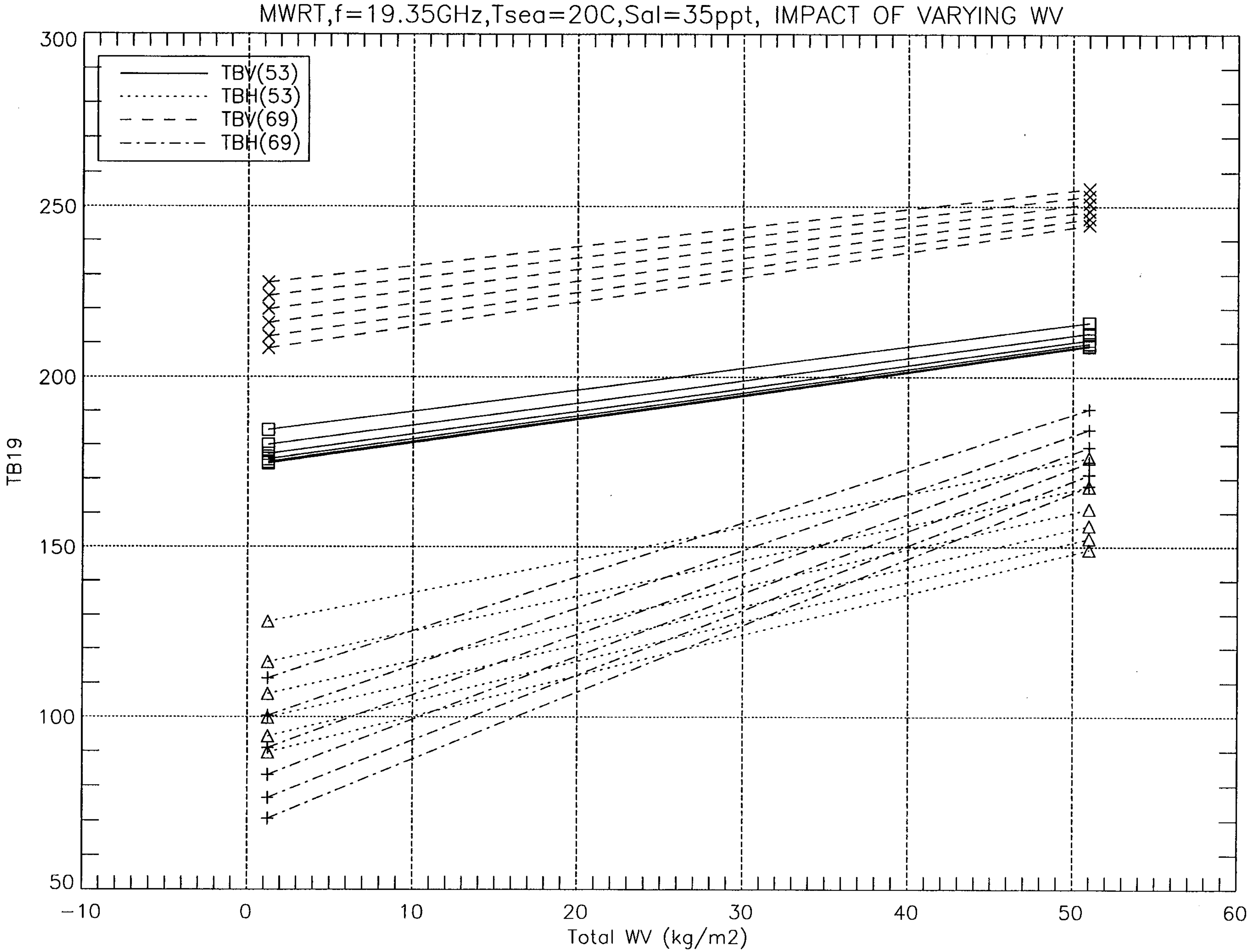
THE PLOT ON PAGE 52 SHOWS T_B FOR V AND H POLARIZATION PLOTTED AS A FUNCTION OF BOTH EIA AND OCEAN SURFACE WIND SPEED. THIS SIMULATION CORRESPONDS TO ATMOSPHERIC PROFILE 30, WITH A TOTAL INTEGRATED WATER VAPOR OF 1.2 kg/m^2. TWO SOLID VERTICAL LINES INDICATE THE 53.1° AND 69° INCIDENCE ANGLE CASES. NOTE THE BEHAVIOR OF $T_{B,H}$ WITH EIA, DECREASING AS A FUNCTION OF EIA, INCREASING WITH WIND SPEED. SIMILARLY, FOR $T_{B,V}$, NOTE THAT FOR A GIVEN WIND SPEED, $T_{B,V}$ INCREASES WITH EIA, HOWEVER, AT A GIVEN EIA THE DEPENDENCE ON WIND SPEED CHANGES FROM 53.1° TO 69°. AT THE LOWER EIA, $T_{B,V}$ INCREASES WITH WIND SPEED, WHEREAS AT 69° $T_{B,V}$ DECREASES WITH WIND SPEED. SIMILARLY, THE PLOT ON PAGE 53 SHOWS THE SAME RELATIONSHIPS, BUT THIS TIME FOR A TOTAL INTEGRATED WATER VAPOR OF 51 kg/m^2. FOR THIS CASE THE IMPACT OF THE ATMOSPHERIC EMISSION TERMS IS VERY IMPORTANT AND CHANGES THE BEHAVIOR OF THE $T_{B,H}$ SIGNAL AND DECREASES THE OVERALL SENSITIVITY OF THE TOTAL T_B SIGNALS TO THE SURFACE CONDITIONS (I.E., WIND SPEED).

THE CHART ON PAGE 54 SHOWS T_B AS A FUNCTION OF TOTAL WATER VAPOR, EIA AND WIND SPEED. THE EIA VARIATION IS GIVEN BY THE CHANGE IN LINE STYLE, WHILE THE WIND SPEED VARIATION IS SHOWN AT GIVEN TWV AS THE VARIATION IN THE POSITION OF THE SYMBOLS (THIS CORRESPONDS TO A TOTAL VARIATION OF U_W = 0–25 M/SEC). NOTE THE DECREASE IN VARIATION DUE TO WIND SPEED WITH INCREASING TWV. ALSO NOTE HOW THE RELATIVE VALUES OF $T_{B,V}$ AND $T_{B,H}$, AT THE 2 EIA VALUES, CHANGE AS TWV INCREASES.


MWRT, f=19.35GHz, Tsea=20C,S=35ppt,TWV=1.24 kg/m2, no clouds
Uw = 0 m/sec
Uw = 10 m/sec
Uw = 20 m/sec
Brightness Temperature (K)
EIA (D)
0
50
100
150
200
250
300
0
20
40
60
80



MWRT, f=19.35GHz, Tsea=20C,S=35ppt,TWV=50.99kg/m2, no clouds
Uw = 0 m/sec
Uw = 10 m/sec
Uw = 20 m/sec
Brightness Temperature (K)
0
100
200
300
0
20
40
60
80
EIA (D)



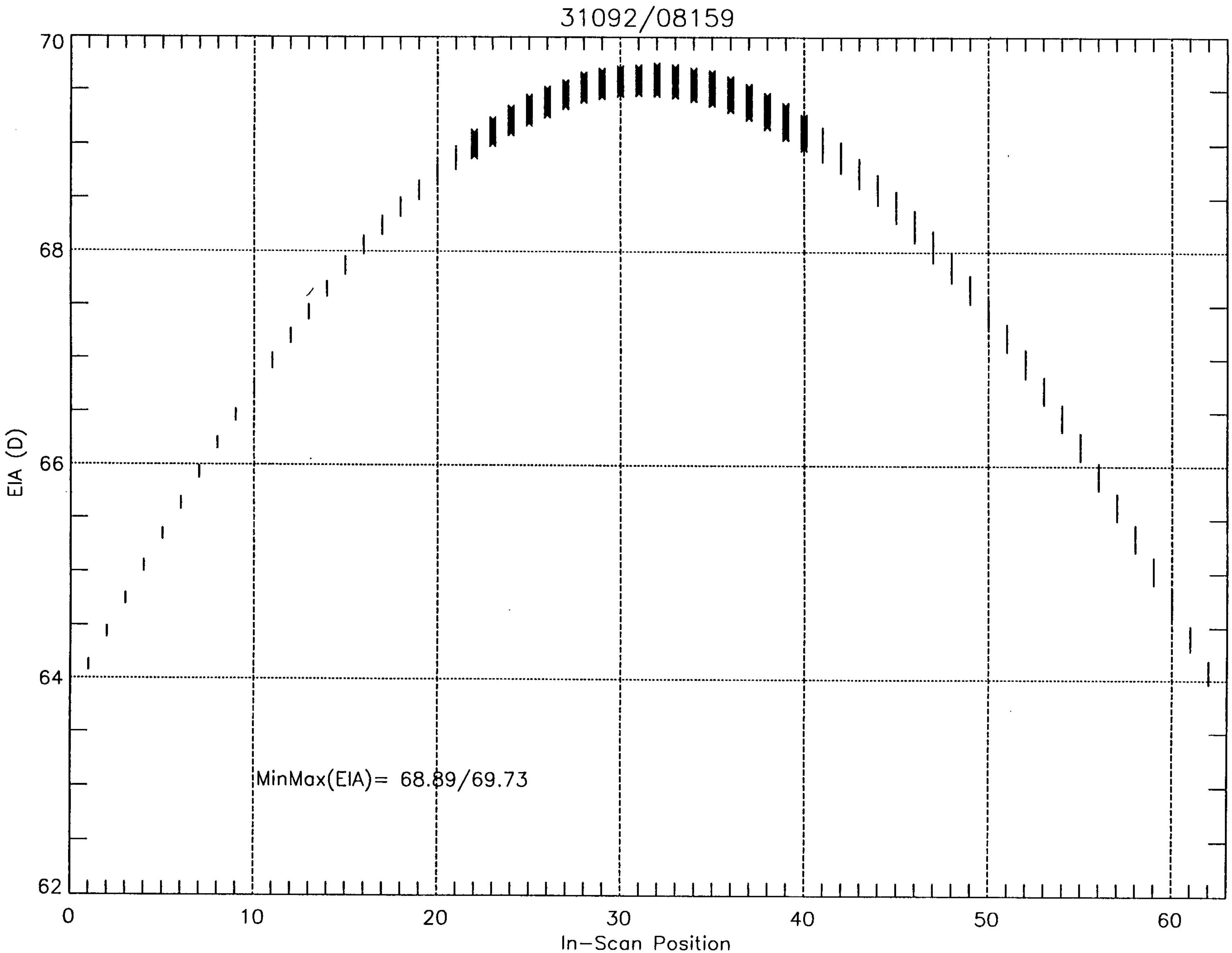
MWRT,f=19.35GHz,Tsea=20C,Sal=35ppt, IMPACT OF VARYING WV
TBV(53)
TBH(53)
TBV(69)
TBH(69)
TB19
Total WV (kg/m2)
300
250
200
150
100
50
−10
0
10
20
30
40
50
60

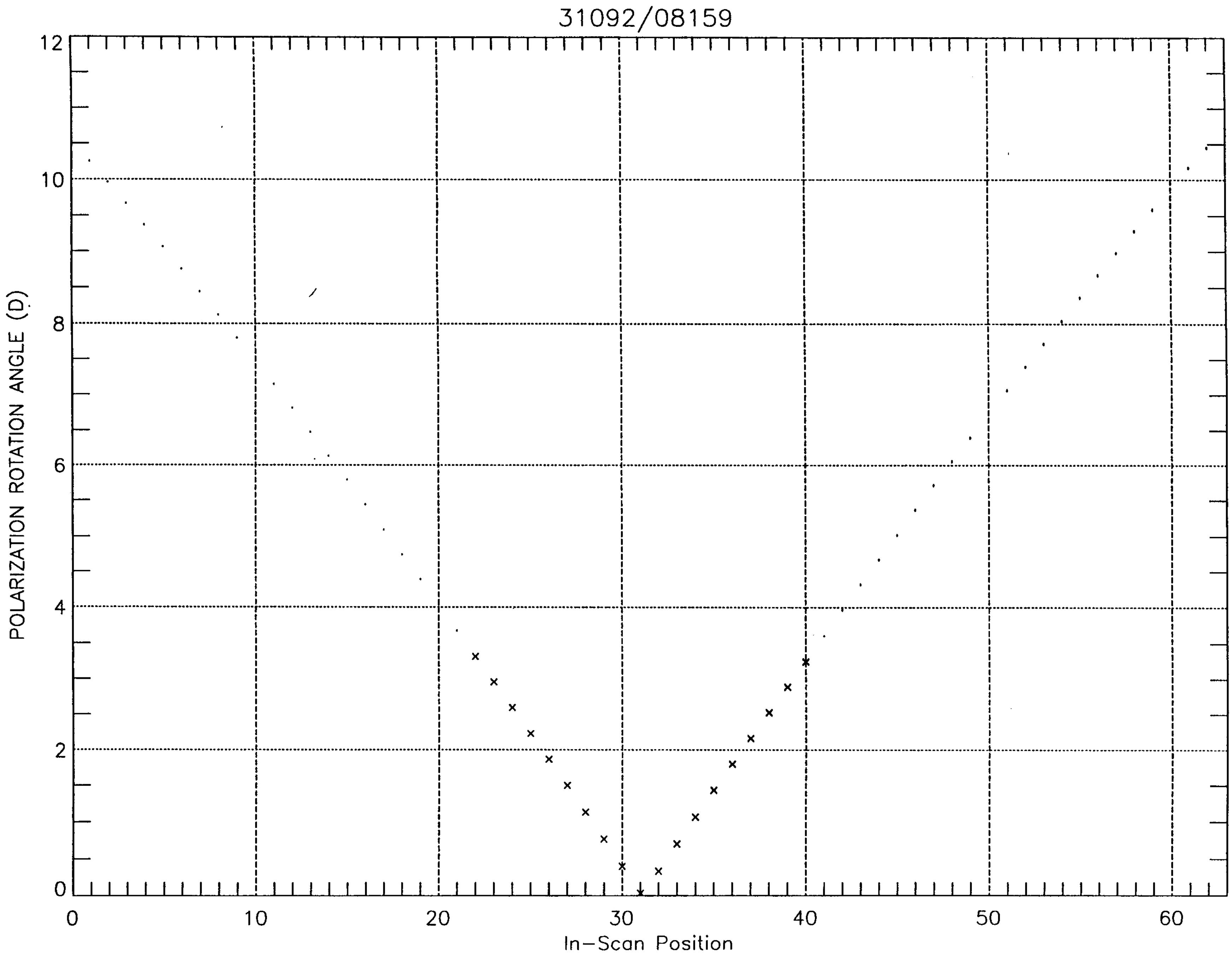
COMPARISON OF F08 WITH F11

- **DESCRIPTION OF DATA ANALYSIS/SELECTION PROCESS**
  - **FROM F08 AND F11 SDR DATA, EXTRACT COINCIDENCES USING THE FOLLOWING CONSTRAINTS**
    - » $|TIME(F08) - TIME(F11)| \leq 30$ MINUTES
    - » $|X(F08) - X(F11)| \leq 30$ KM, WHERE X DENOTES THE PIXEL GEOLOCATION
  - **MAP DATA TO UNIFORMLY SPACED RECTANGULAR GRID**
  - **SELECT CORRESPONDING F08 AND F11 PIXELS WITH**
    - » **T_B WITHIN VALID RANGE**
    - » **OPEN OCEAN SURFACE TYPE**
    - » **VALID WIND SPEED DATA (0–25.3 m/sec range)**
    - » **NO RAIN**
  - **FOR PITCHED F08 DATA**
    - » **RESTRICT TO ±N PIXELS ABOUT SCAN CENTER TO MINIMIZE VARIATION OF EIA AND POLR (SEE FIGURES)**

VARIATION OF EIA AND POLR WITH SCAN POSITION

THE NEXT 2 CHARTS ILLUSTRATE THE VARIATION OF EARTH INCIDENCE ANGLE AND POLARIZATION ROTATION ANGLE (POLR) WITH SCAN POSITION. FOR THE HIGHEST PITCH ANGLE (–10.65°) THERE IS SIGNIFICANT VARIATION OF EIA AND POLR WITH SCAN POSITION. TO MINIMIZE THIS EFFECT, ONLY ±N PIXELS ARE TAKEN ABOUT SCAN CENTER. THIS IS ILLUSTRATED IN THESE PLOTS FOR THE N=9 CASE, BY BOLD FACE SYMBOLS.


31092/08159
EIA (D)
In-Scan Position
MinMax(EIA)= 68.89/69.73
70
68
66
64
62
0
10
20
30
40
50
60



31092/08159
POLARIZATION ROTATION ANGLE (D)
In–Scan Position
0
2
4
6
8
10
12
0
10
20
30
40
50
60

COMPARISON OF F08 WITH F11

- STATISTICAL ANALYSIS AND COMPARISON
  - FOR EACH COINCIDENCE PAIR (F08 AND F11) COMPUTE
    - » MEAN AND STDEV OF TB
    - » MIN/MAX T_B
    - » DIFFERENCE F08–F11, MEAN AND STDEV, MIN/MAX
    - » CORRELATION (F08, F11)
- BASELINE COMPARISON (ZERO PITCH)
- HIGHEST PITCH (–10.65°) COMPARISON
- DETAILED EXAMPLES

BASELINE COMPARISON OF F08 WITH F11

- **Bottom Line: If NO Meteorological Differences, Correlation > 0.95 for all 5 channels over ocean**
- **Time Coincidence Restriction NOT strong enough to ensure this. Therefore each coincident pair has to be inspected.**
- **Comparison with Cal/Val very encouraging**

AVERAGE F08–F11 TEMPERATURE

(OVER OCEAN)

	NRL	AEROSPACE	
	Delta T	Delta T	Std. Dev.
$T_{B,V}(19)$	-0.7K	-0.6K	4.7K
$T_{B,H}(19)$	-0.3K	-0.1K	7.9K
$T_{B,V}(22)$	-1.6K	-1.6K	3.1K
$T_{B,V}(37)$	-0.3K	-0.2K	4.3K
$T_{B,H}(37)$	-1.0K	-1.0K	7.9K

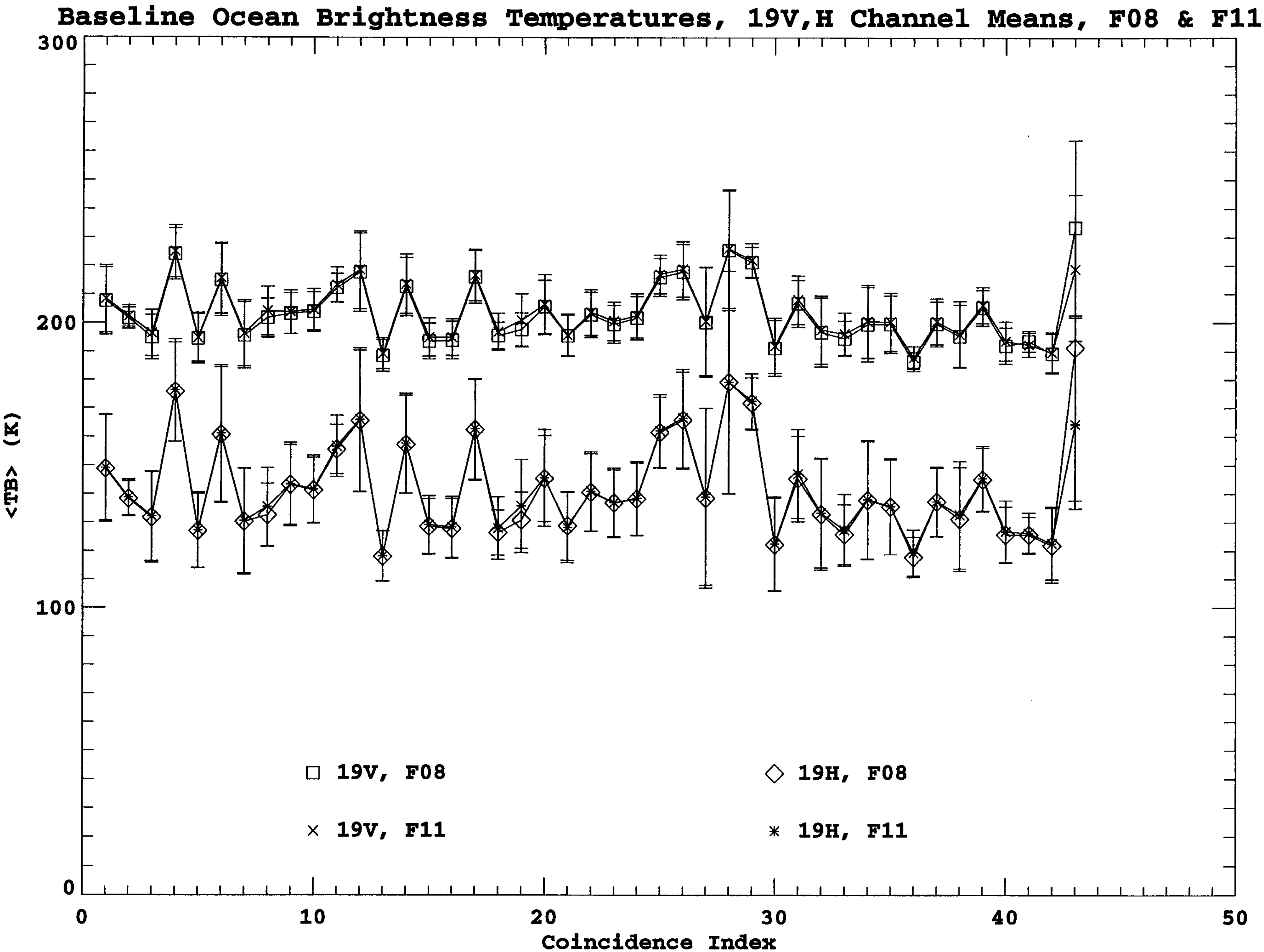
BASELINE COMPARISON OF BRIGHTNESS TEMPERATURES

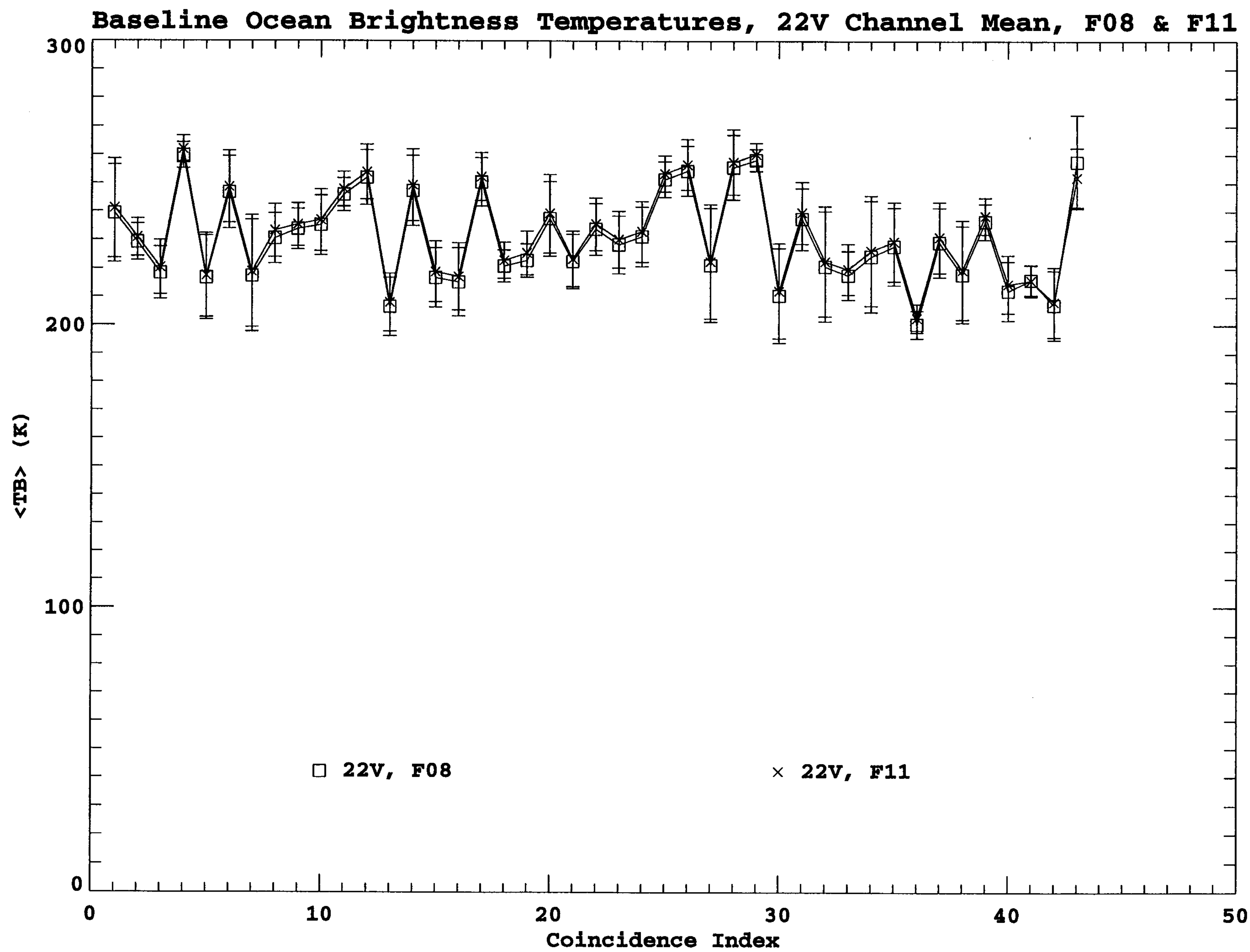
THE FIGURES ON PAGES 62–64 COMPARE THE AVERAGE BRIGHTNESS TEMPERATURE OF F08 TO F11 AT EACH INDIVIDUAL COINCIDENCE FOR THE 5 LOW FREQUENCY CHANNELS. THE DATA SHOWN ARE OVER OCEAN ONLY.

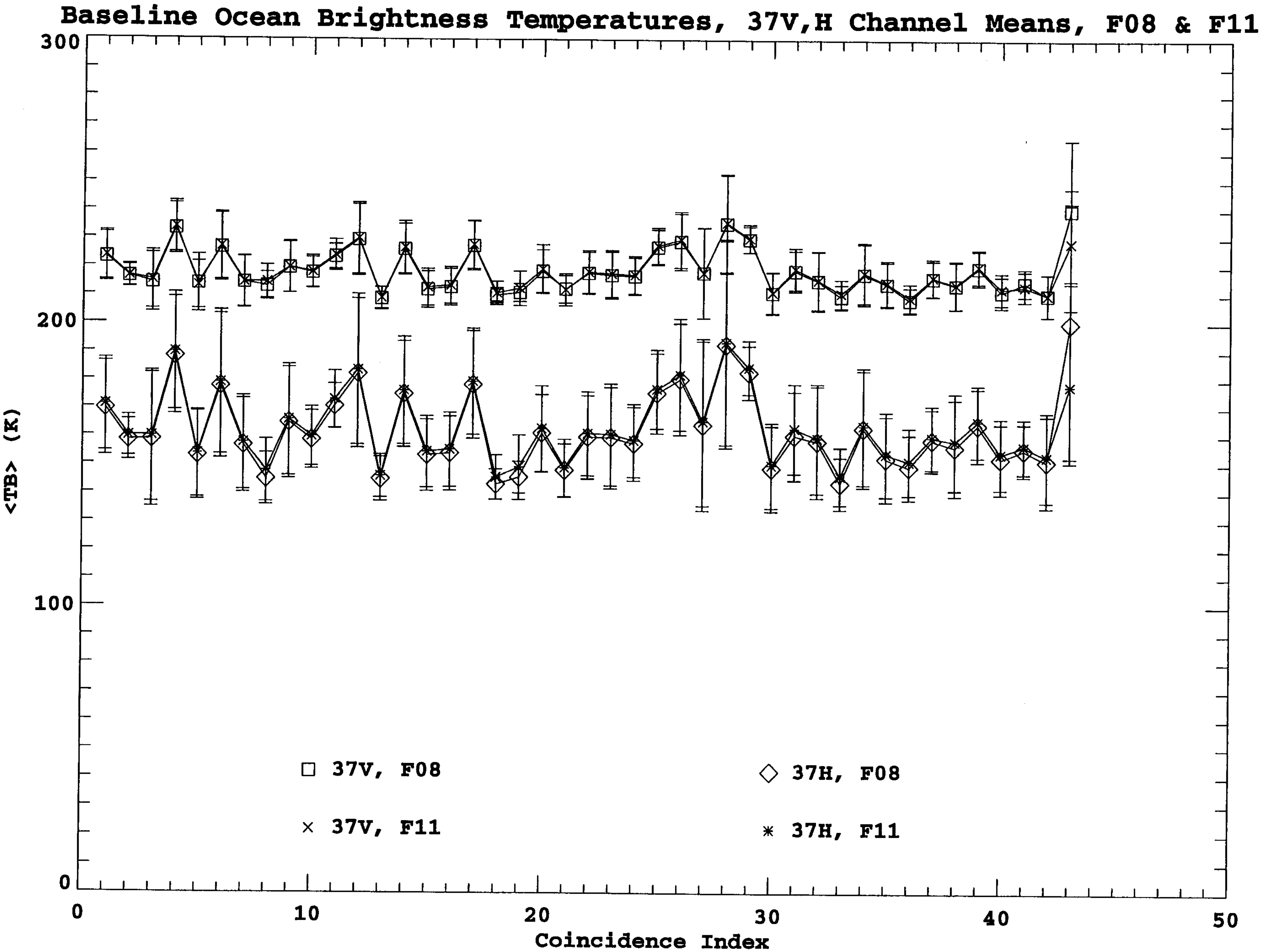
THE FIGURES ON PAGES 65–66 SHOW THE CORRELATION BETWEEN F08 AND F11 BRIGHTNESS TEMPERATURES FOR EACH COINCIDENCE AT THE 5 LOW FREQUENCIES. THE DATA SHOWN ARE OVER OCEAN ONLY.

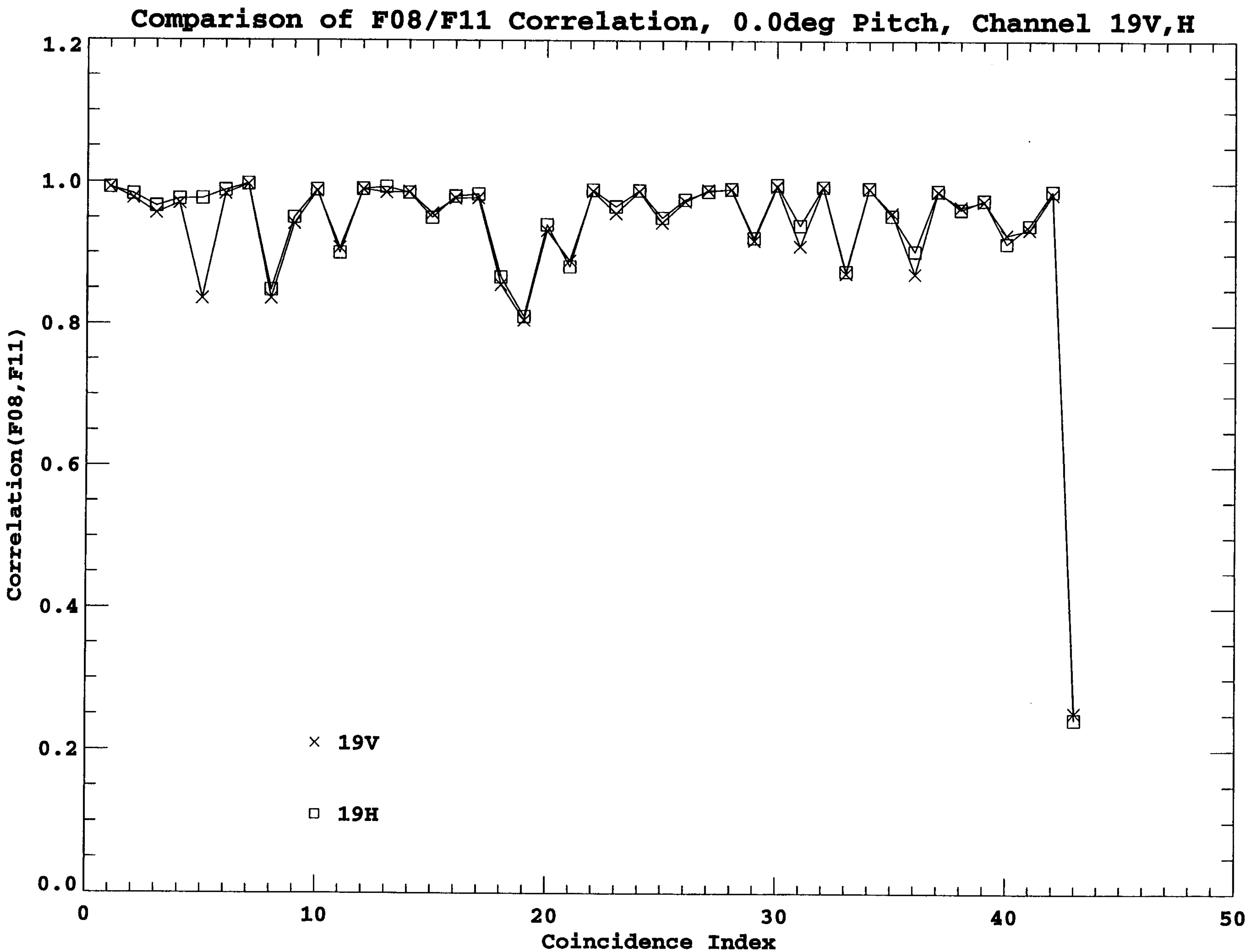
EACH COINCIDENT EVENT CONSISTED OF ANYWHERE BETWEEN 10 TO 5000 ACTUAL DATA POINTS. THE POINTS WERE CHOSEN ACCORDING TO THE COINCIDENCE CRITERIA AND THEN FURTHER REDUCED BY CHOOSING ONLY THOSE POINTS WITH OCEAN SURFACE TYPE.

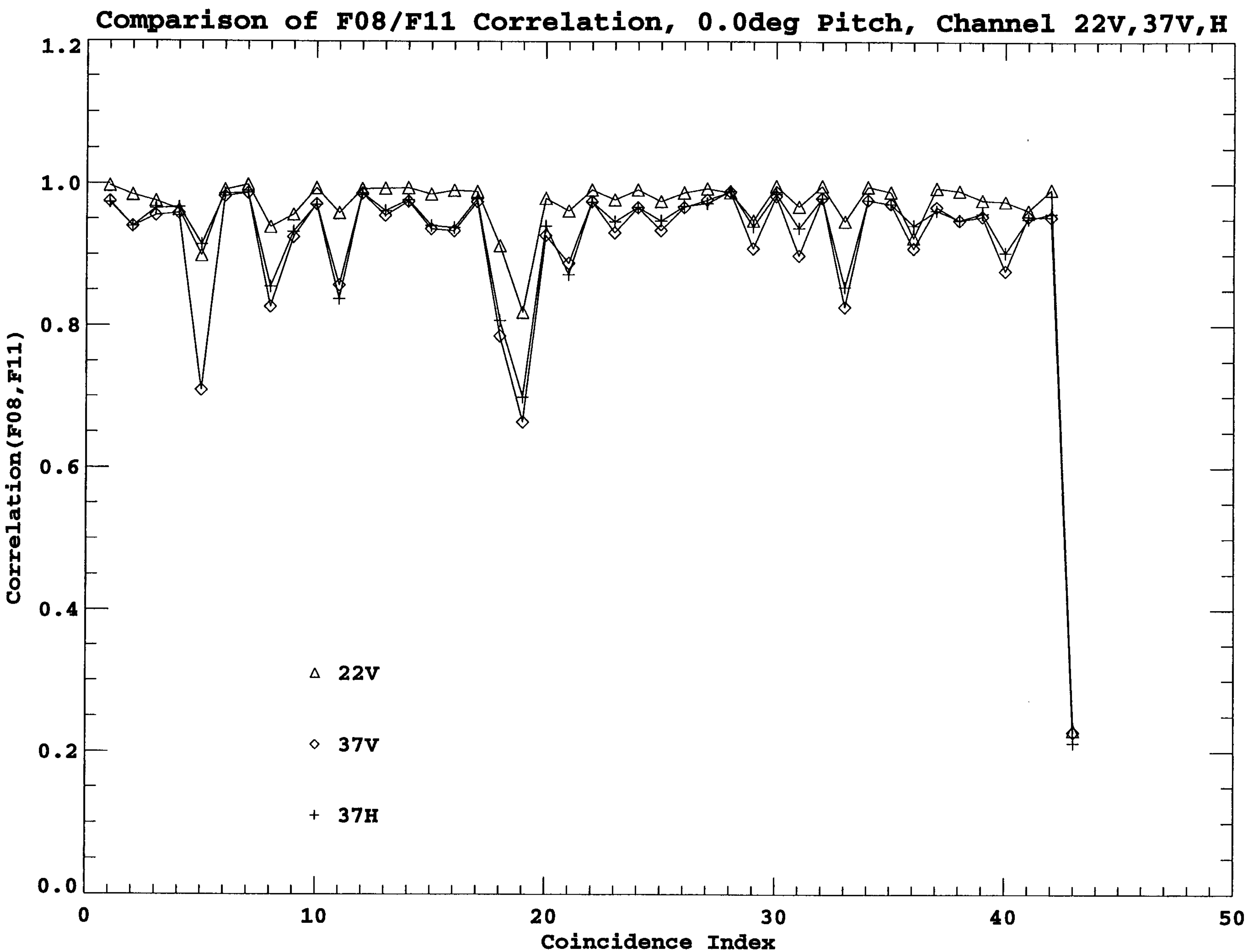
THE CORRELATION COEFFICIENTS WERE CALCULATED USING EACH POINT IN A COINCIDENCE AND NOT JUST THE AVERAGE OVER THE ENTIRE COINCIDENT EVENT.


Baseline Ocean Brightness Temperatures, 19V,H Channel Means, F08 & F11
300
200
100
0
<TB> (K)
0
10
20
30
40
50
Coincidence Index
19V, F08
19H, F08
19V, F11
19H, F11


Baseline Ocean Brightness Temperatures, 22V Channel Mean, F08 & F11
<TB> (K)
Coincidence Index
0
100
200
300
0
10
20
30
40
50
□ 22V, F08
× 22V, F11


Baseline Ocean Brightness Temperatures, 37V,H Channel Means, F08 & F11
300
200
100
0
<TB> (K)
0
10
20
30
40
50
Coincidence Index
37V, F08
37V, F11
37H, F08
37H, F11


Comparison of F08/F11 Correlation, 0.0deg Pitch, Channel 19V,H
Correlation(F08,F11)
Coincidence Index
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
19V
19H


Comparison of F08/F11 Correlation, 0.0deg Pitch, Channel 22V,37V,H
Correlation(F08,F11)
Coincidence Index
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
22V
37V
37H

DETAILED COMPARISON OF BASELINE REV. NO.s 31064 & 08131

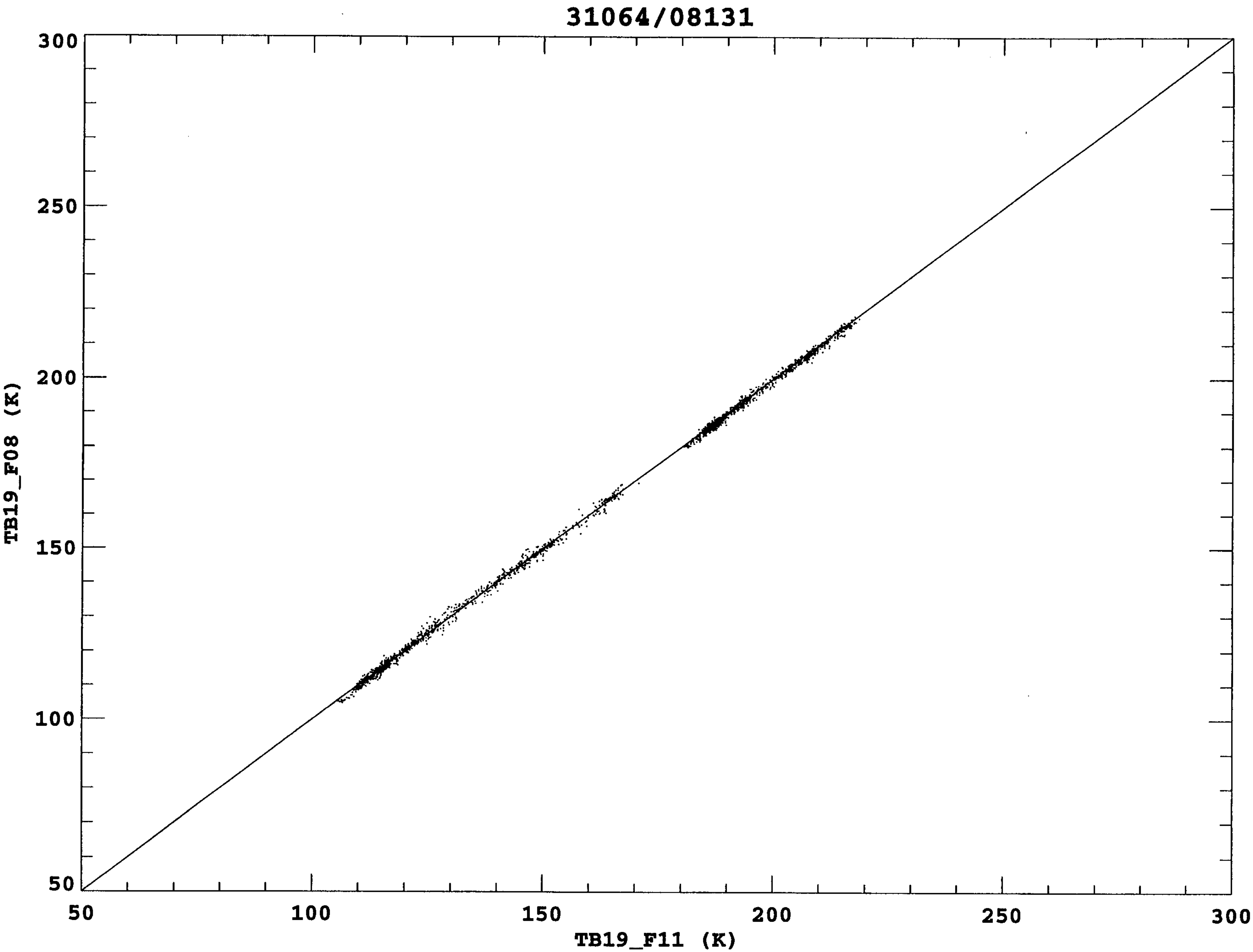
THE FOLLOWING SEQUENCE OF PLOTS COMPARES AND CONTRASTS THE DATA TAKEN FROM F08 REVOLUTION NUMBER 31064 AND F11 REVOLUTION NUMBER 8131. THE DATA COMPARED IS LIMITED TO COINCIDENT DATA WITH OCEAN SURFACE TYPE.

THE FIGURES ON PAGES 68A-68C ARE SCATTER PLOTS OF THE CHANNEL 19, 22, AND 37 BRIGHTNESS TEMPERATURES. THE WARMER OF THE TWO "CLUMPS" APPARENT IN THE 19 AND 37 PLOTS IS THE "V" CHANNEL DATA. THE COOLER IS THE "H" CHANNEL DATA. NOTE THE VERY STRONG CORRELATION.

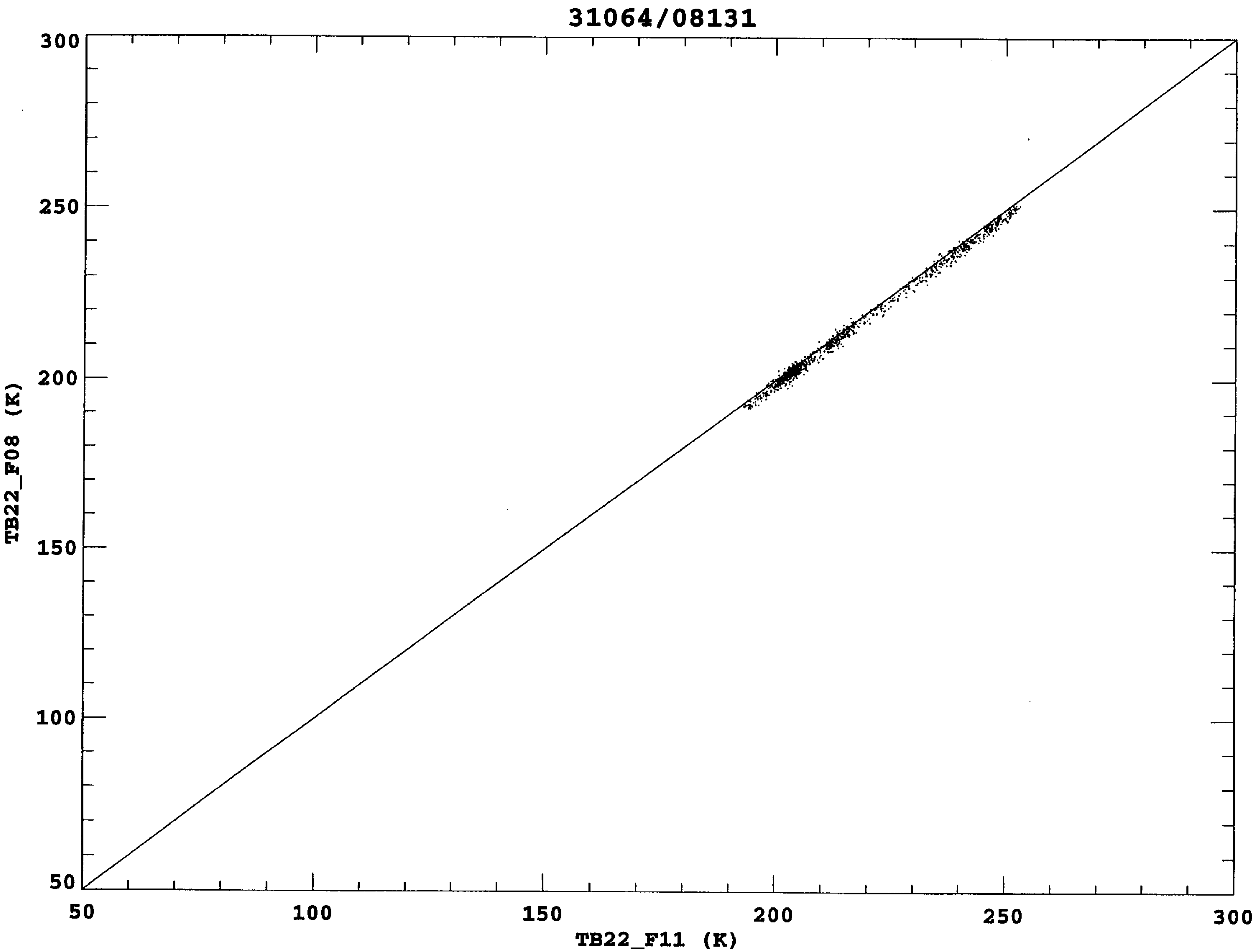
THE FIGURES ON PAGES 68D-68H SHOW THE SAME DATA IN THE FORM OF HISTOGRAMS. THE SOLID LINE IS THE F11 HISTOGRAM AND THE DOT/DASH LINE IS THE F08 DATA.

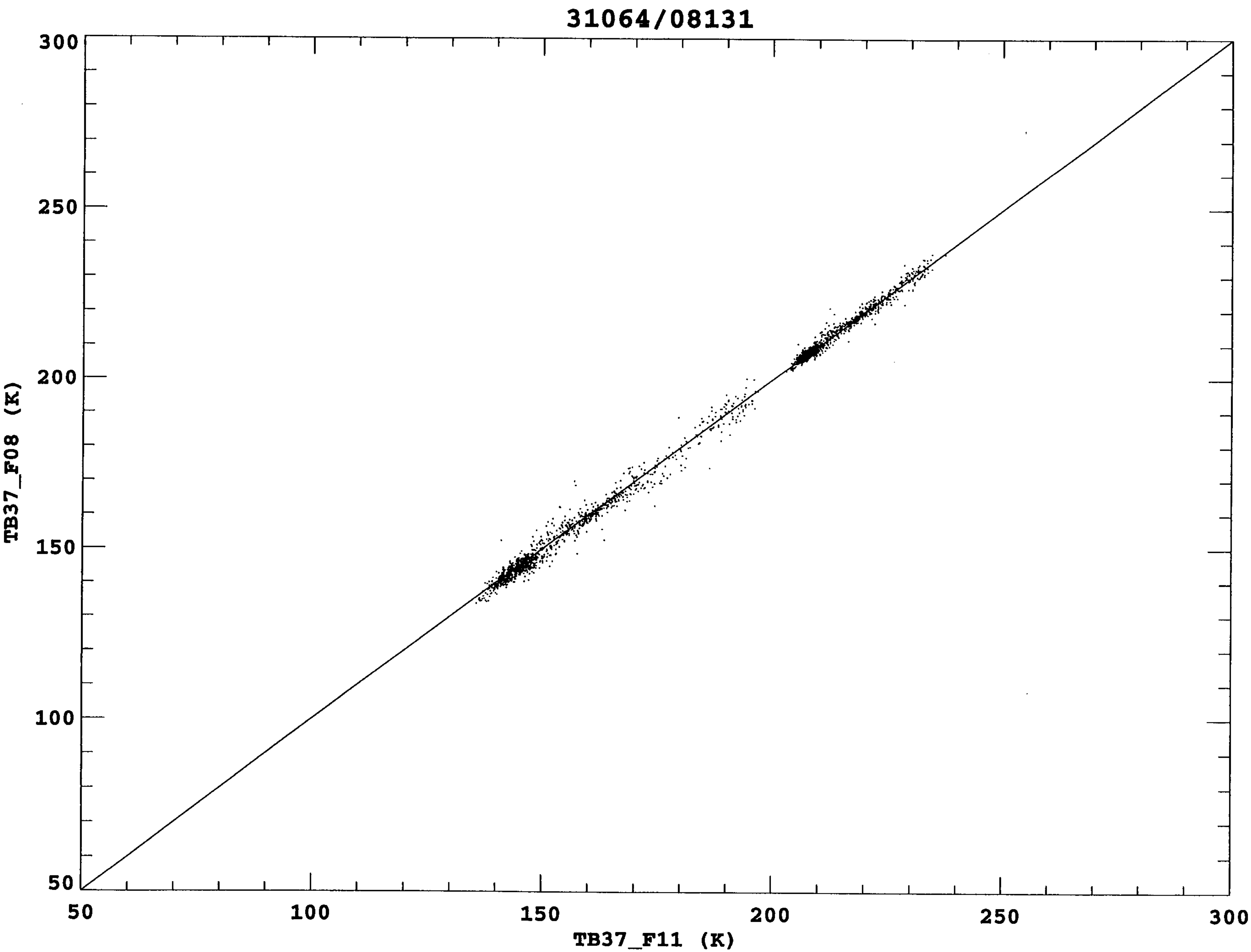
THE FIGURES ON PAGES 68I-68J SHOW THE WIND SPEED AND WATER VAPOR CONTENT RESPECTIVELY. THESE EDR VALUES WERE DERIVED FROM F11 DATA ONLY.

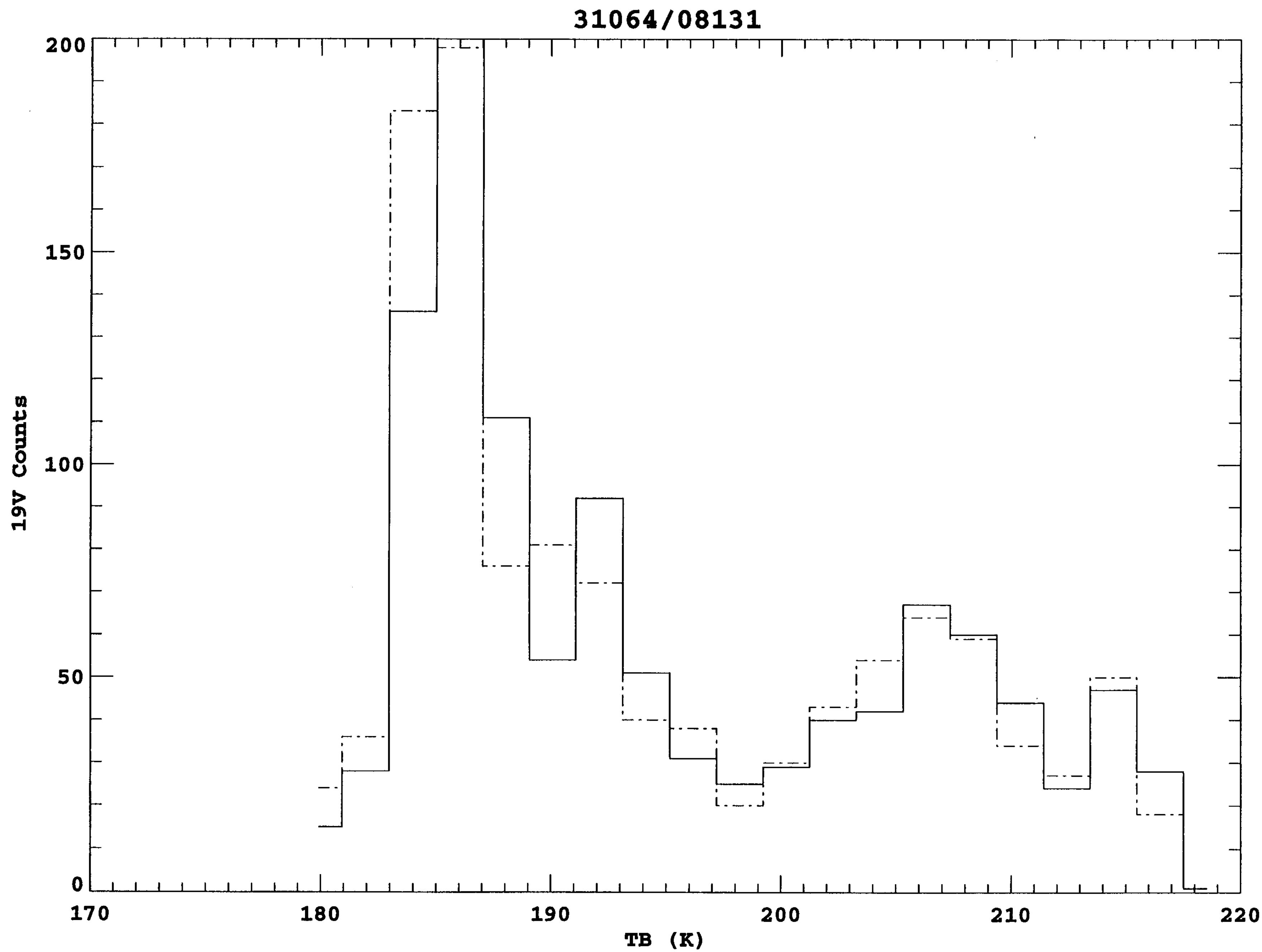
THE FIGURES ON PAGES 68K-68P SHOW THE CORRELATION BETWEEN WIND SPEED (AS CALCULATED FROM THE F11 DATA) AND BRIGHTNESS TEMPERATURE FOR EACH SATELLITE AND EACH FREQUENCY. AGAIN, THE WARMER "CLUMP" OF POINTS IN THE 19 AND 37 PLOTS IS THE "V" CHANNEL AND THE COOLER "CLUMP" IS THE "H" CHANNEL.



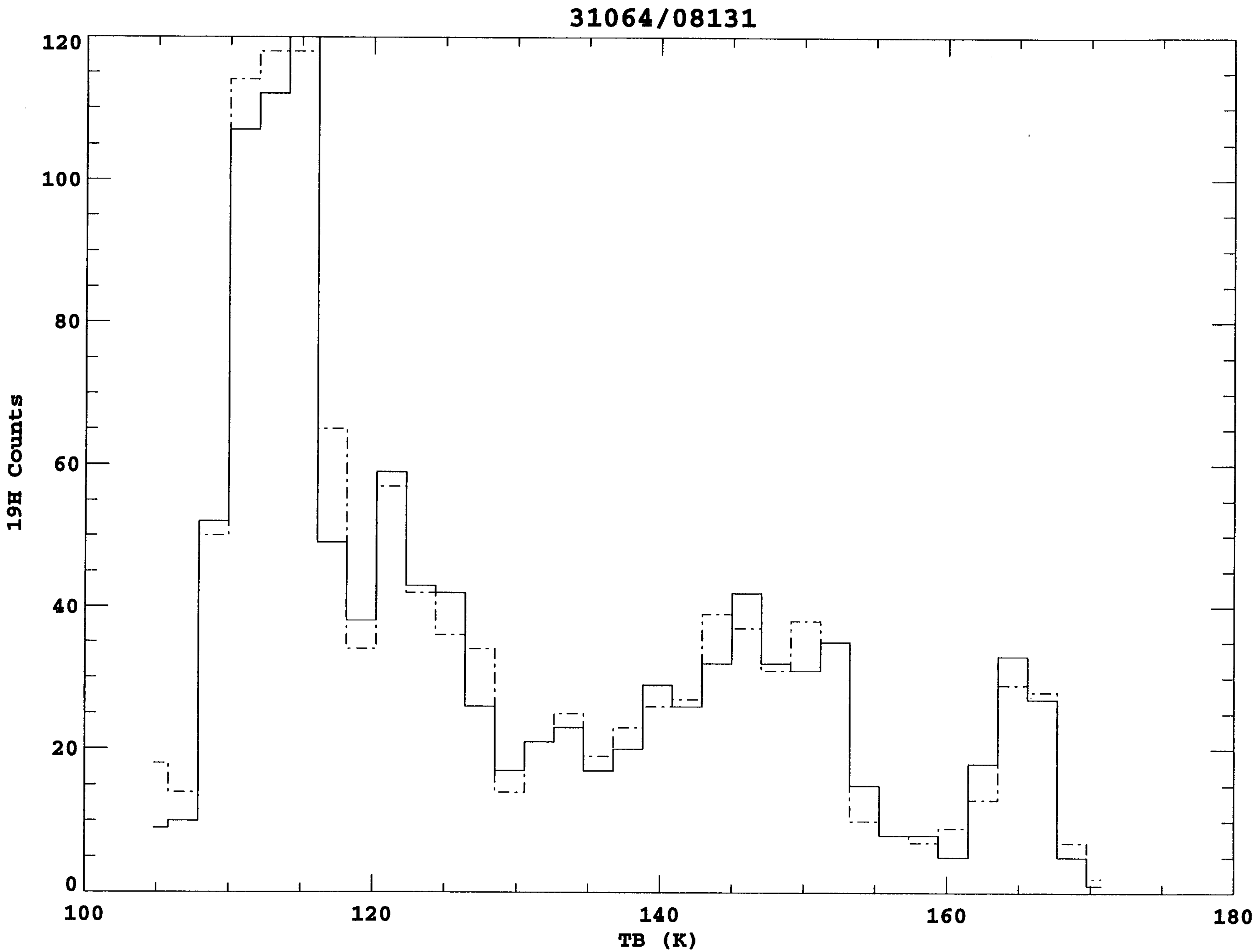
31064/08131
300
250
200
150
100
50
50
100
150
200
250
300
TB19_F08 (K)
TB19_F11 (K)

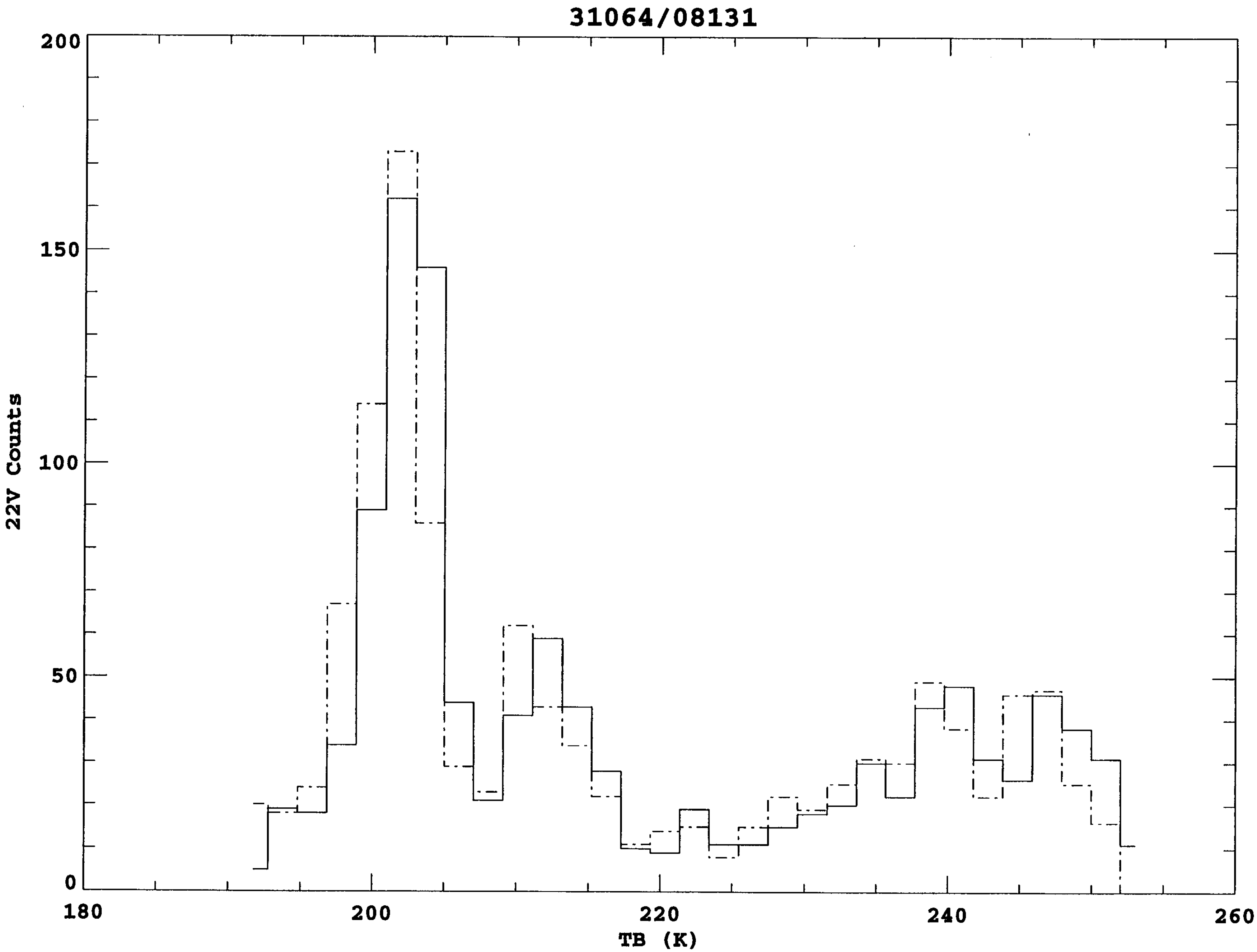

31064/08131
TB22_F08 (K)
TB22_F11 (K)
300
250
200
150
100
50
50
100
150
200
250
300


31064/08131
TB37_F08 (K)
TB37_F11 (K)
50
100
150
200
250
300

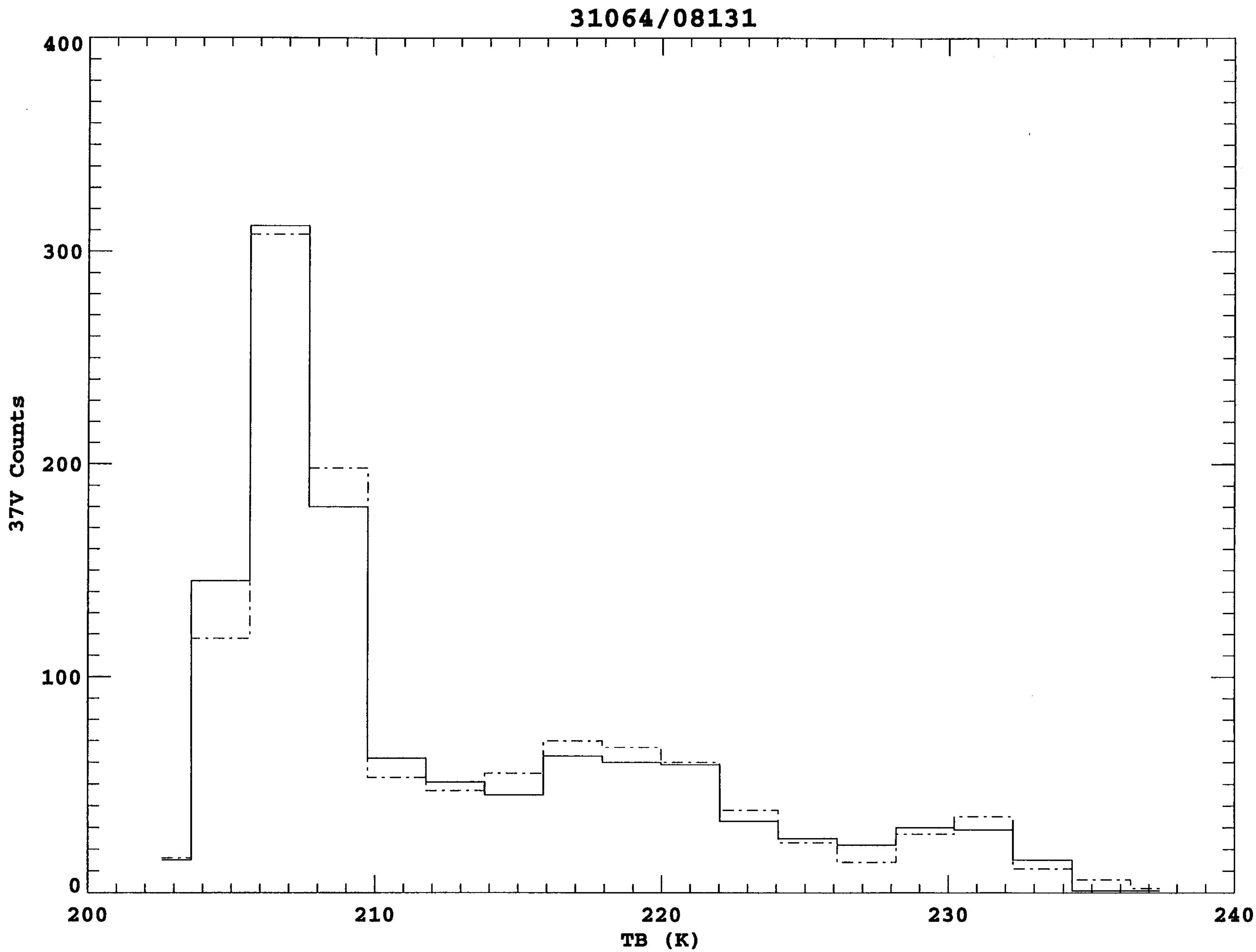

31064/08131
19V Counts
200
150
100
50
0
170
180
190
200
210
220
TB (K)

68D

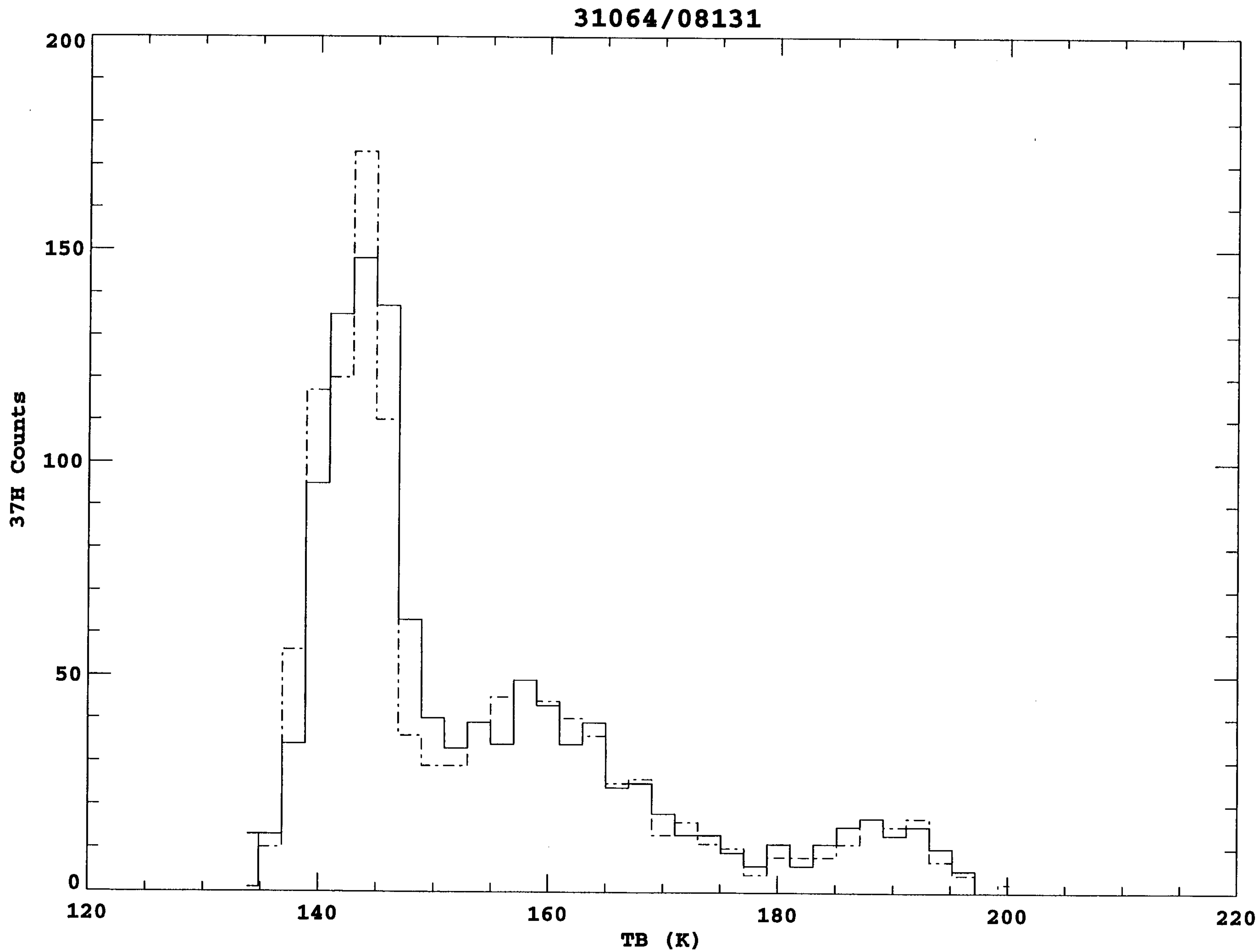

31064/08131
120
100
80
60
40
20
0
19H Counts
100
120
140
160
180
TB (K)



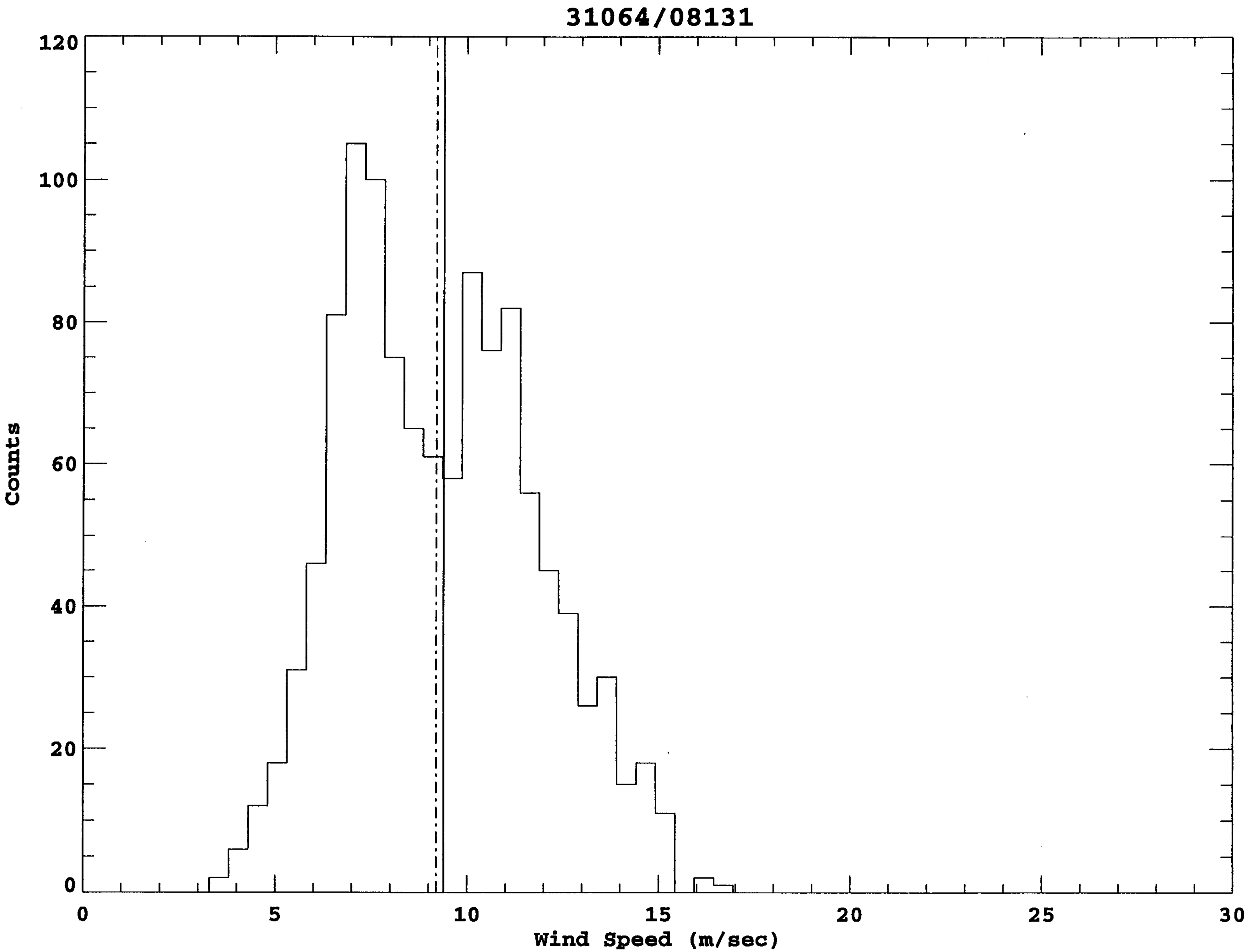
68F

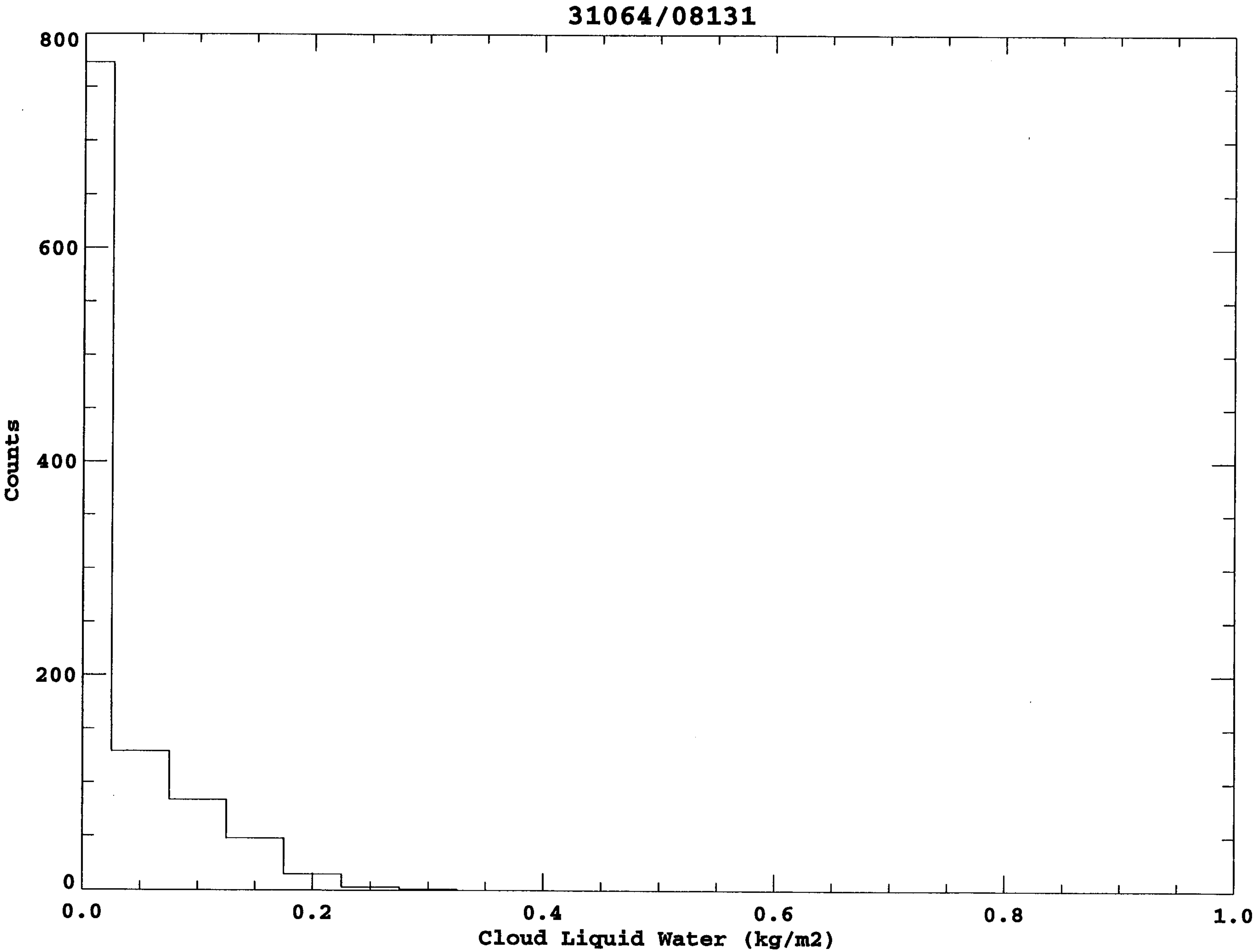

31064/08131
37V Counts
400
300
200
100
0
200
210
220
230
240
TB (K)

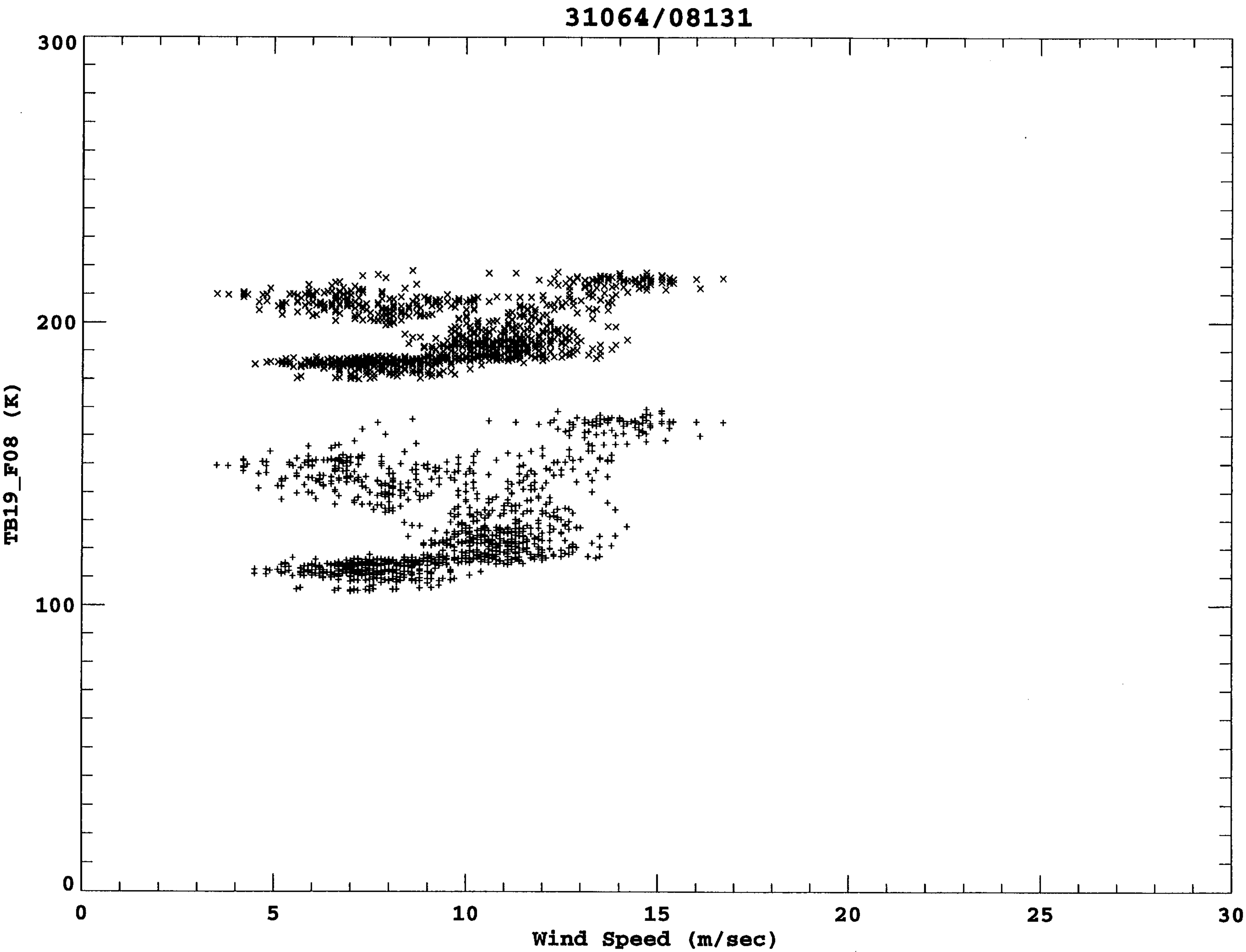
68G


31064/08131
37H Counts
TB (K)
200
150
100
50
0
120
140
160
180
200
220

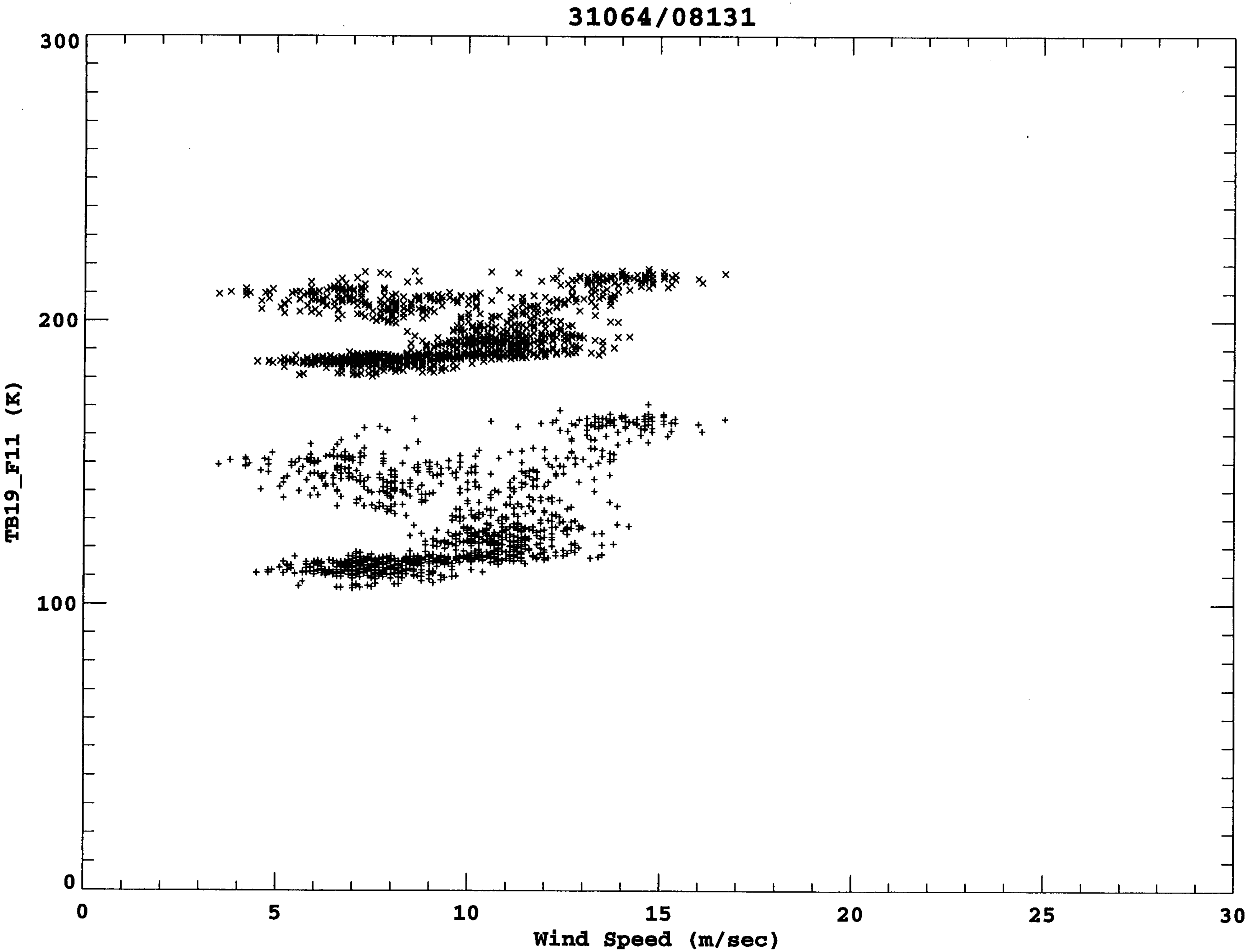
68H

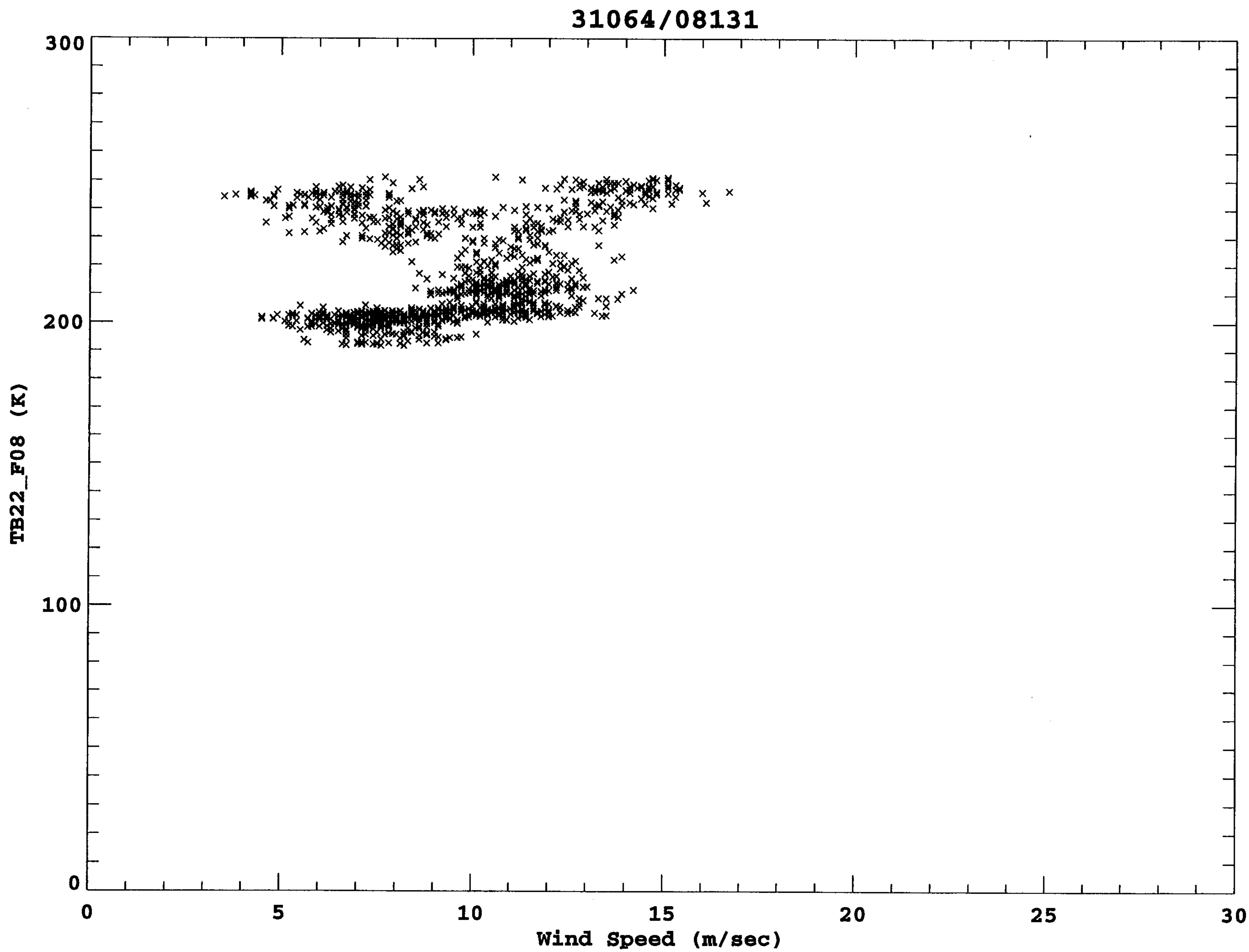

31064/08131
Counts
Wind Speed (m/sec)
0
20
40
60
80
100
120
0
5
10
15
20
25
30


31064/08131
800
600
400
200
0
Counts
0.0
0.2
0.4
0.6
0.8
1.0
Cloud Liquid Water (kg/m2)

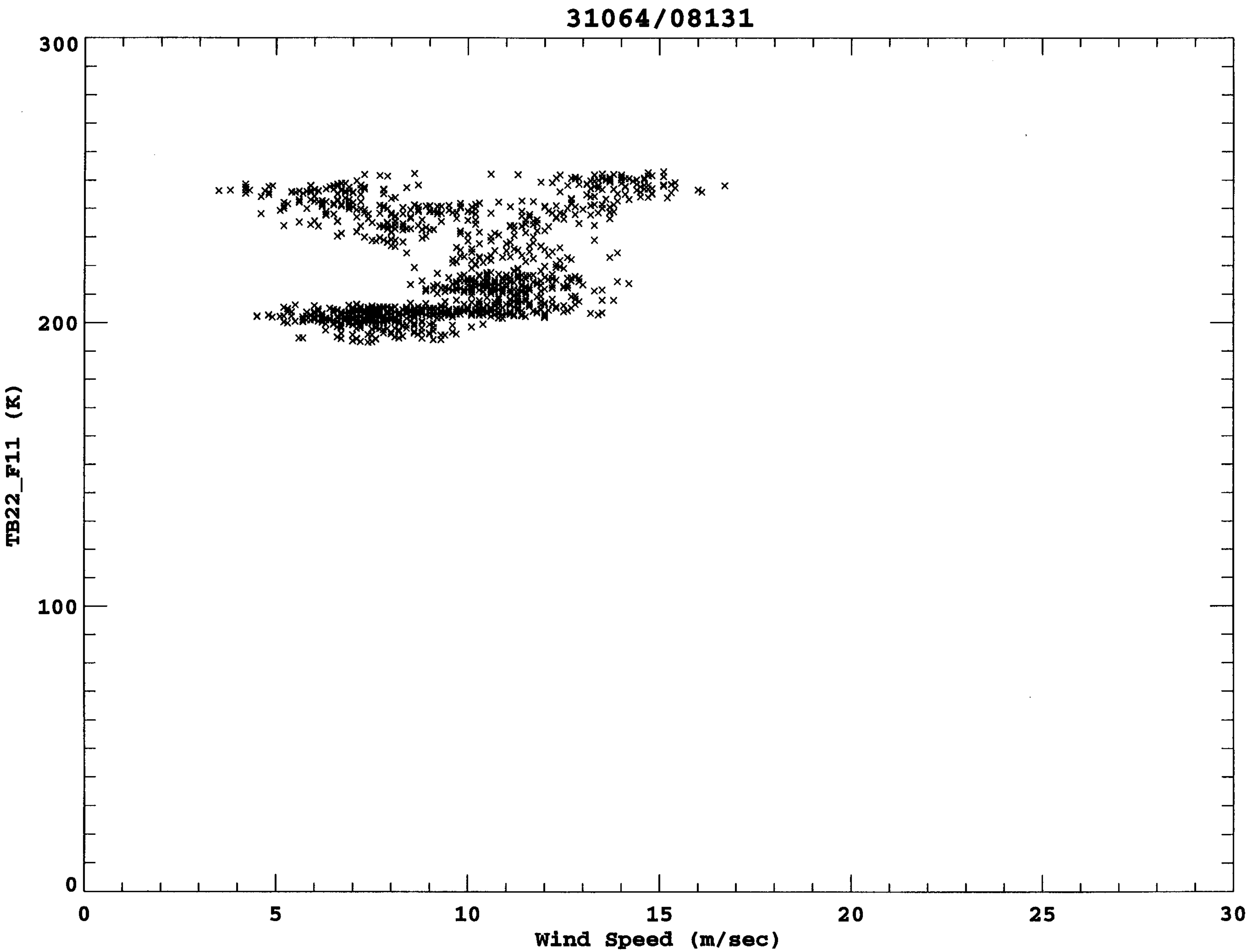

31064/08131
300
200
100
0
TB19_F08 (K)
0
5
10
15
20
25
30
Wind Speed (m/sec)

68K

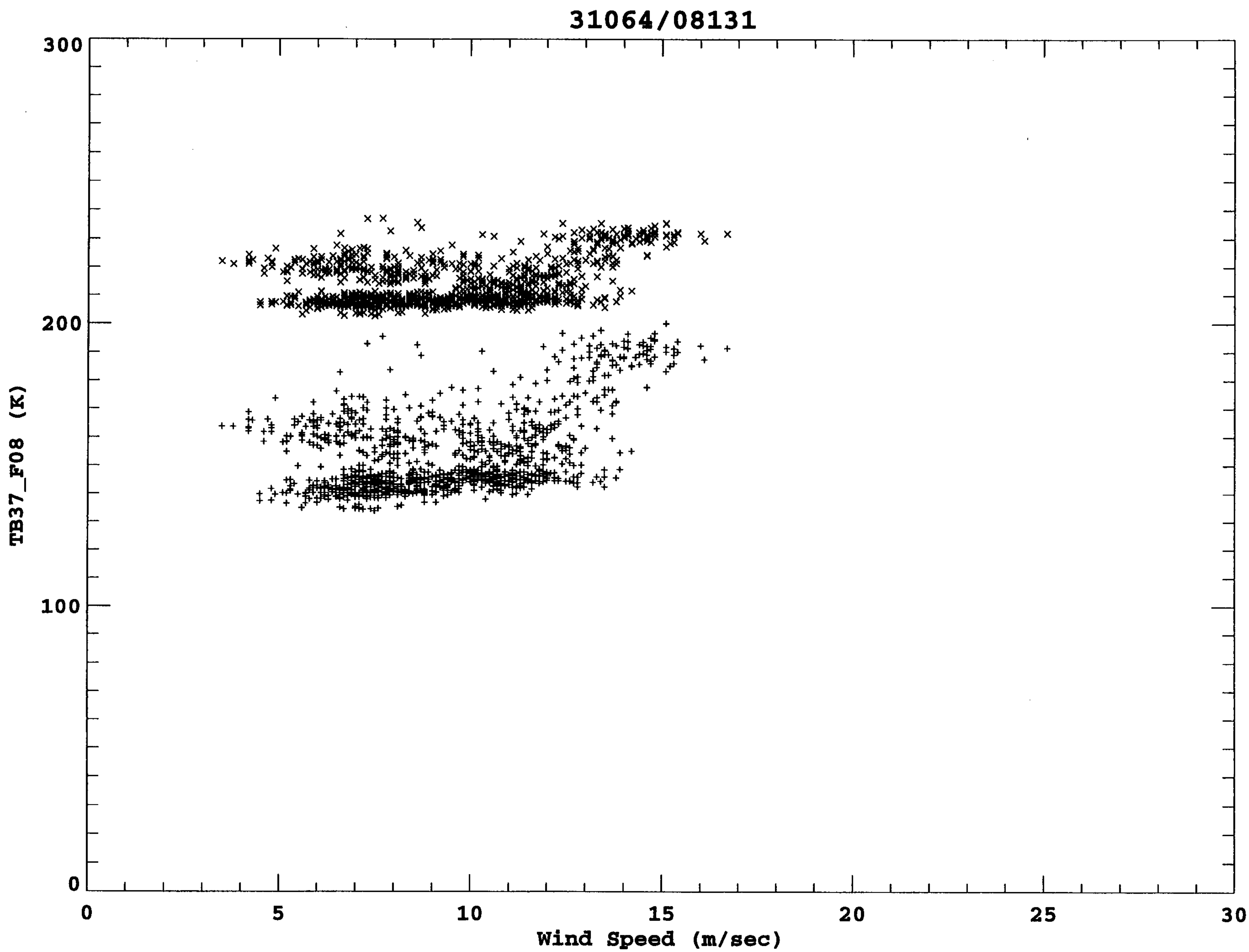

31064/08131
TB19_F11 (K)
Wind Speed (m/sec)
0
100
200
300
0
5
10
15
20
25
30


31064/08131
TB22_F08 (K)
300
200
100
0
0
5
10
15
20
25
30
Wind Speed (m/sec)

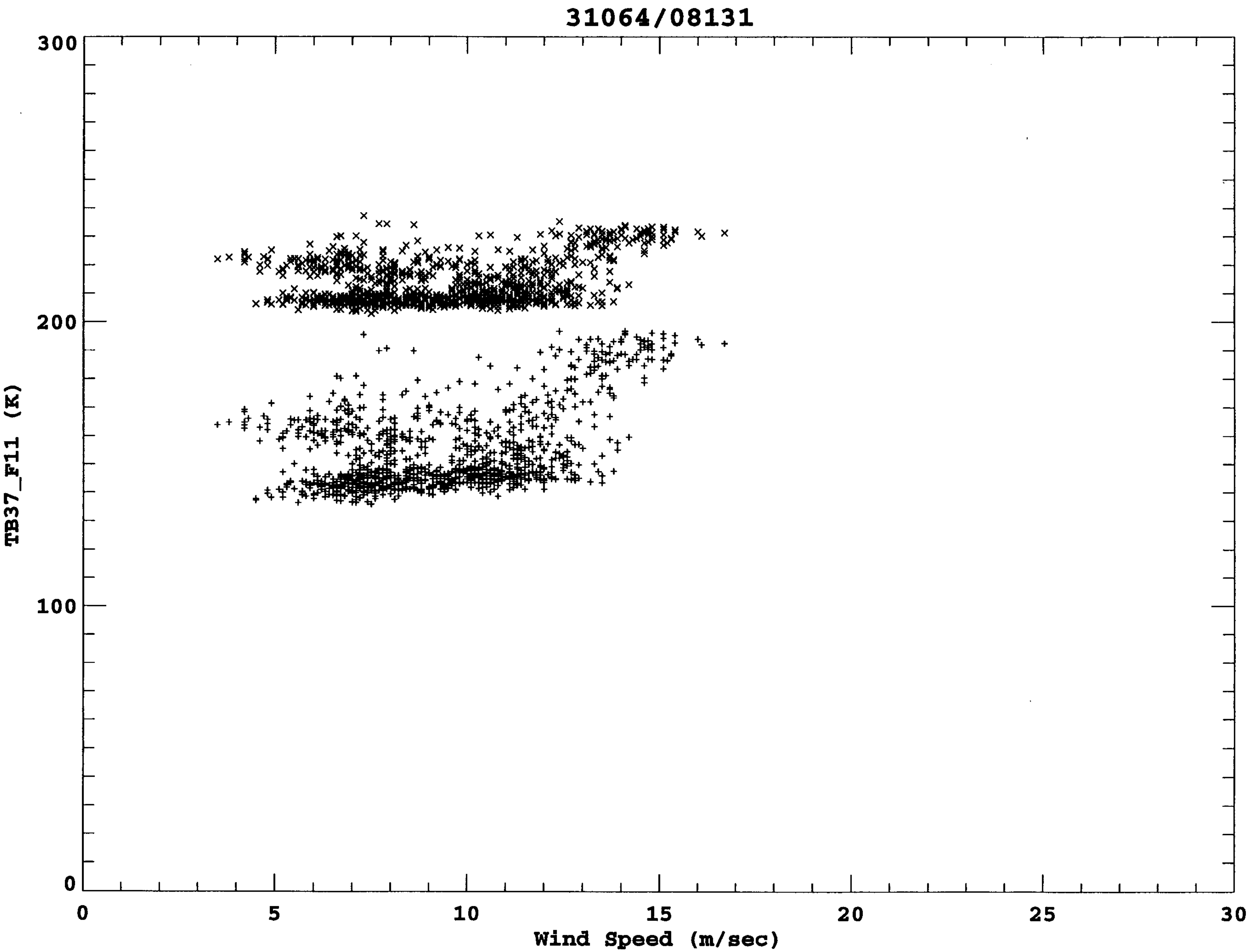
68M


31064/08131
TB22_F11 (K)
300
200
100
0
0
5
10
15
20
25
30
Wind Speed (m/sec)

68N



31064/08131
300
200
100
0
TB37_F08 (K)
0
5
10
15
20
25
30
Wind Speed (m/sec)



31064/08131
TB37_F11 (K)
Wind Speed (m/sec)
300
200
100
0
0
5
10
15
20
25
30

COMPARISON OF F08 WITH F11

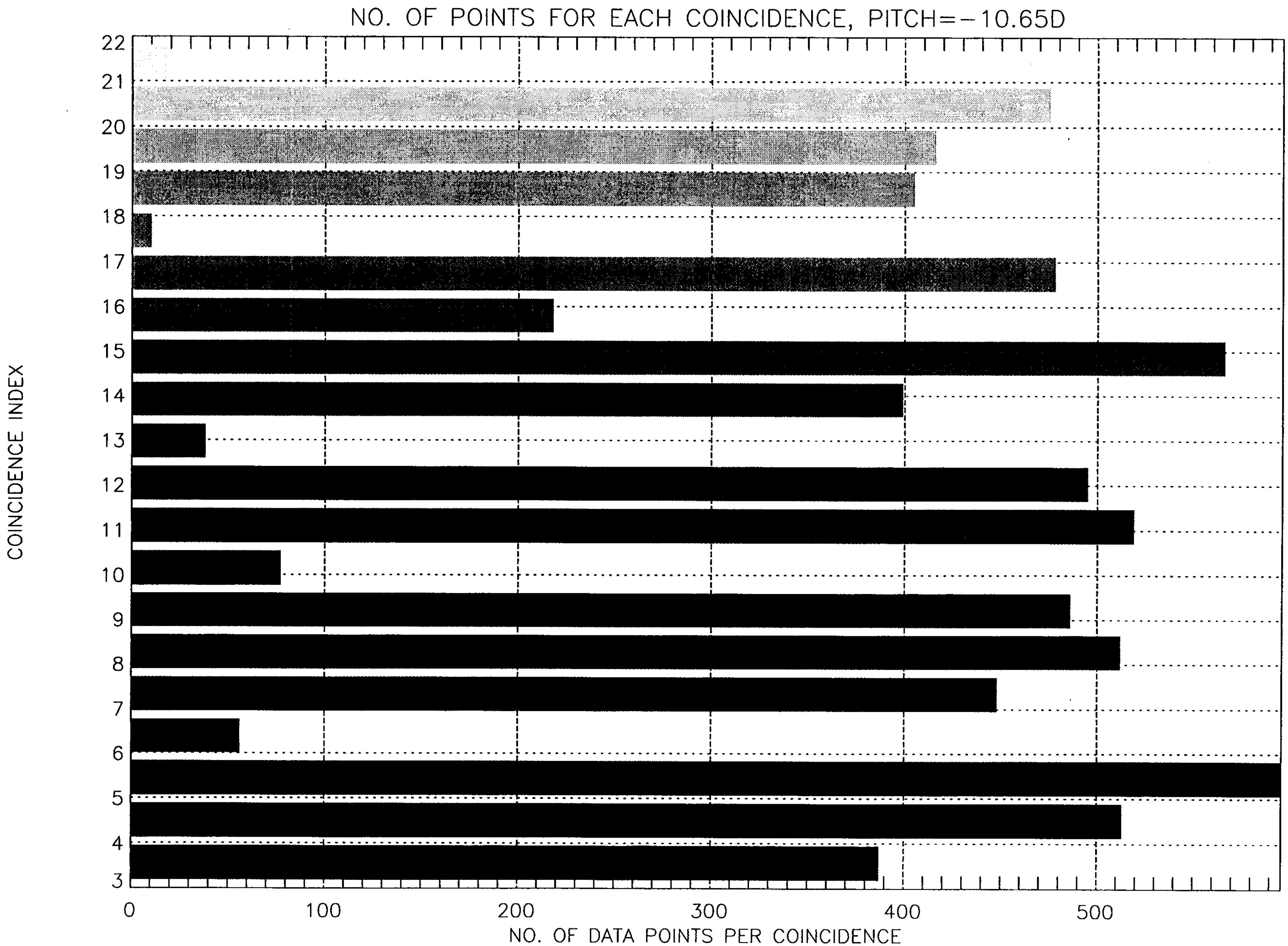
- HIGHEST EIA CASE (–10.65° PITCH)
  - RESULTS OF STATISTICAL ANALYSIS
  - FIGURES
    - » <T_B>
    - » CORRELATION (F08, F11)

- DISCUSSION

- DETAILED EXAMPLE

NUMBER OF POINTS PER COINCIDENCE REGION

THIS CHART SHOWS A BAR GRAPH GIVING THE NUMBER OF POINTS PER COINCIDENCE REGION STUDIED TO DATE. NOTE THAT MOST OF THE DATASETS HAVE SOMEWHERE IN THE RANGE OF 400–500 POINTS, WHILE THE SMALLEST HAS ONLY 10.

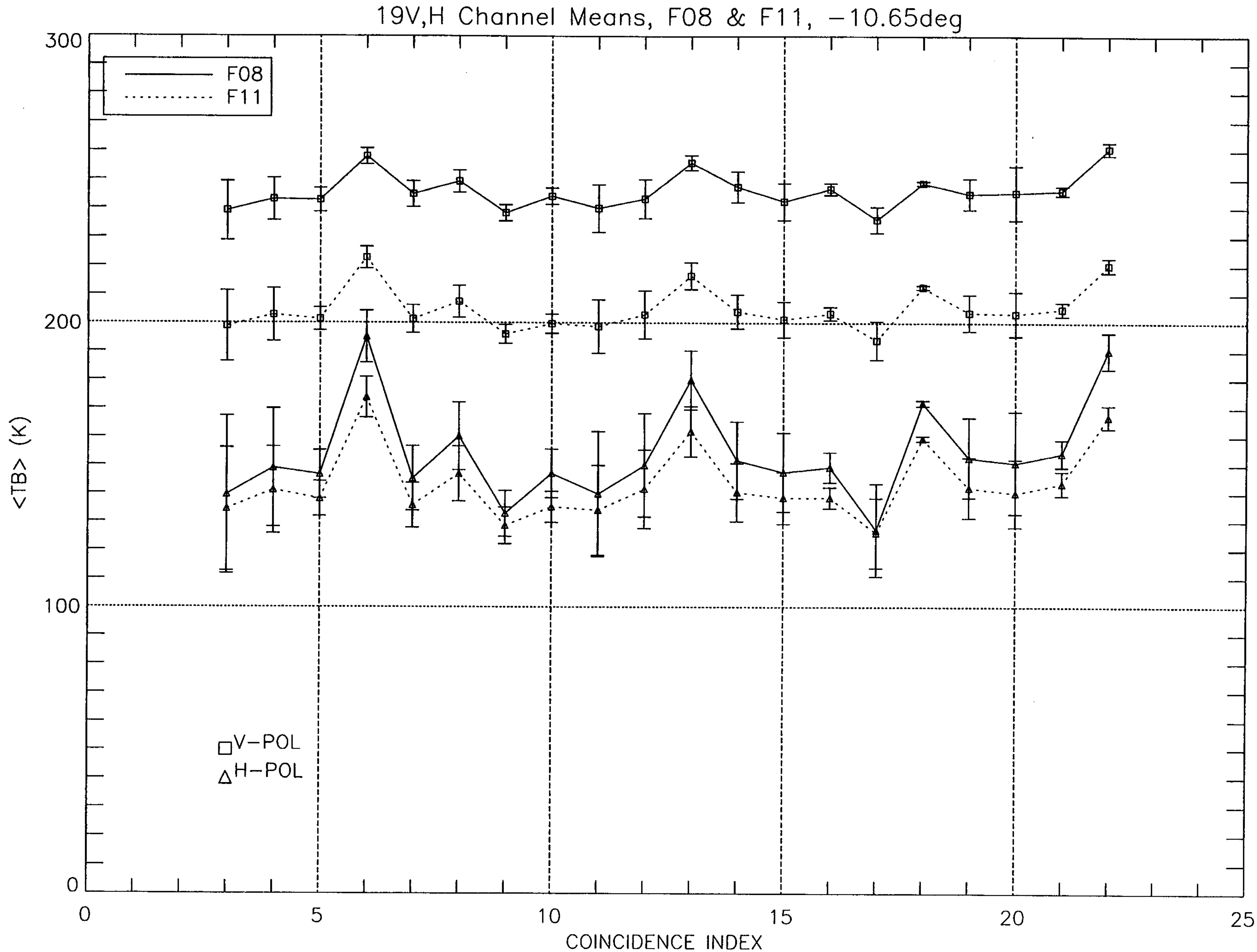

NO. OF POINTS FOR EACH COINCIDENCE, PITCH=-10.65D
COINCIDENCE INDEX
NO. OF DATA POINTS PER COINCIDENCE
0
100
200
300
400
500
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

STATISTICAL COMPARISON PLOTS
PAGES 73–78

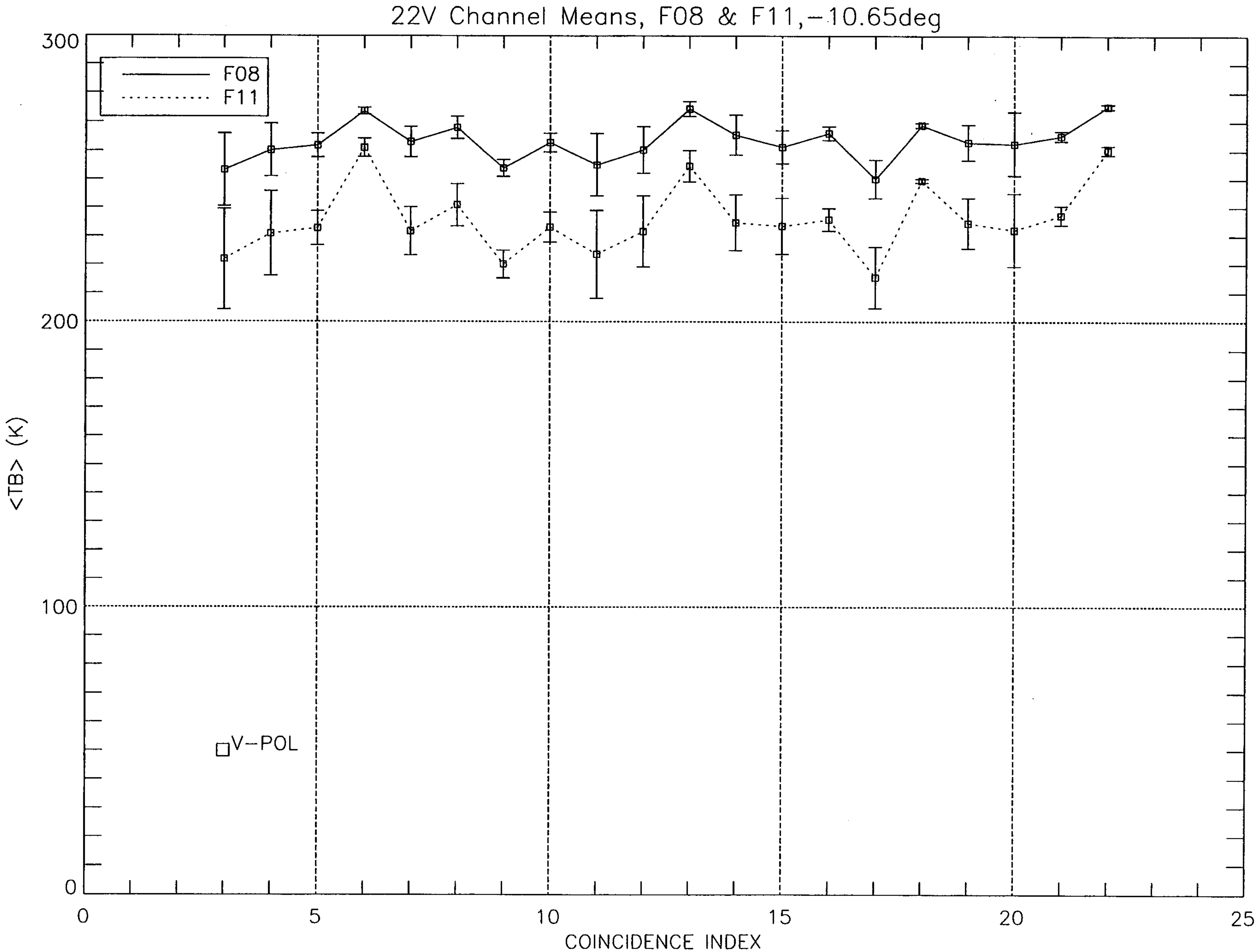
FOR EACH COINCIDENCE REGION BOTH THE MEAN AND STANDARD DEVIATION OF THE BRIGHTNESS TEMPERATURE IS COMPUTED, FOR BOTH F08 AND F11. THESE VALUES ARE SHOWN PLOTTED AS A FUNCTION OF COINCIDENCE (THE COINCIDENCE INDEX IS JUST A BOOKKEEPING PARAMETER) WITH THE ERROR BARS CORRESPONDING TO $\pm$ 1 STANDARD DEVIATION. NOTE HOW WELL THE VARIATION OF $\langle T_B(F08) \rangle$ TRACK THE VARIATION OF $\langle T_B(F11) \rangle$ FOR BOTH THE V AND H CHANNELS.

THE CORRELATION BETWEEN F08 AND F11 IS COMPUTED FOR EACH COINCIDENCE REGION AND SSM/I CHANNEL.

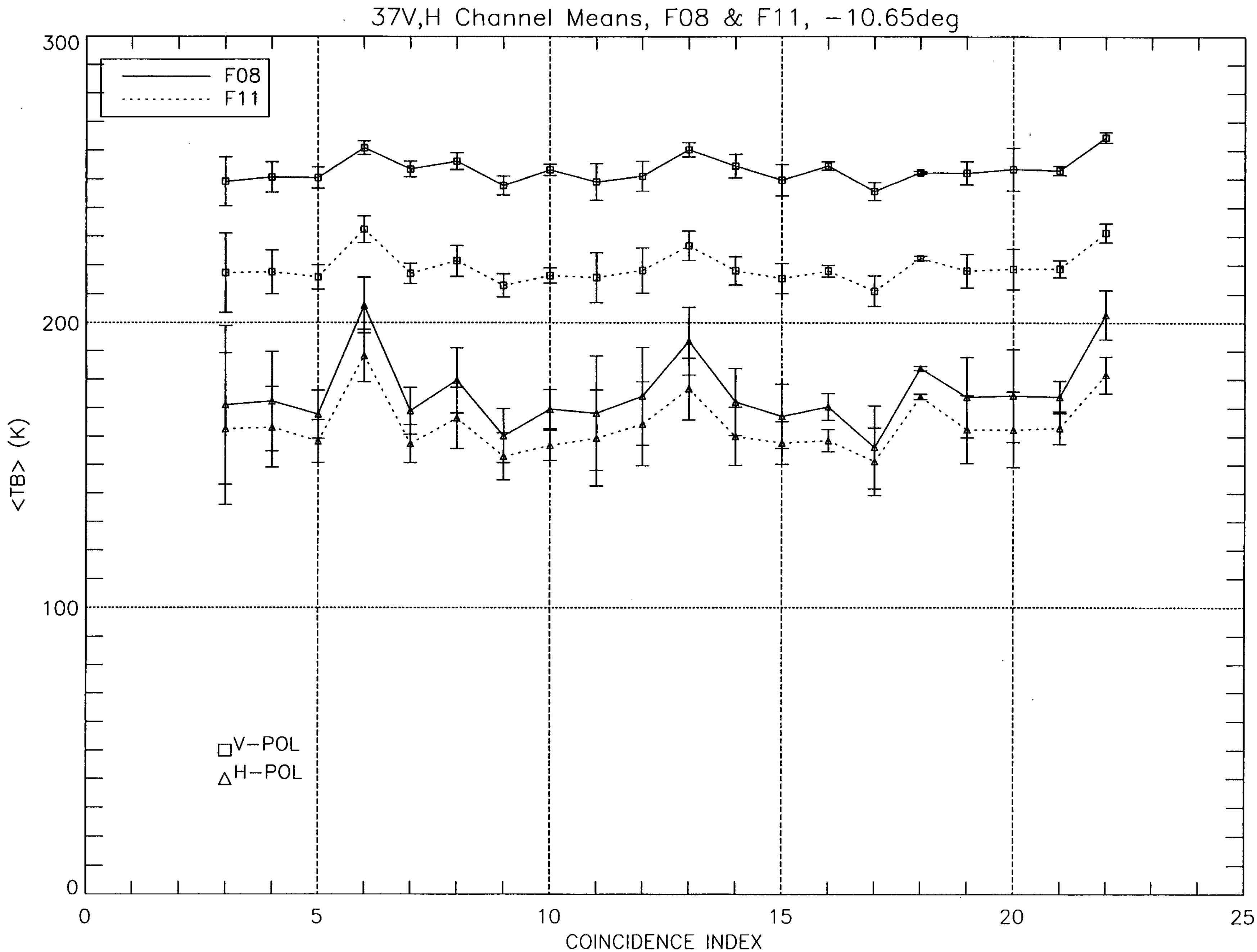
THE DIFFERENCE BETWEEN $T_B(F08)$ AND $T_B(F11)$ IS ALSO COMPUTED AND THE MEAN AND STANDARD DEVIATION OF THESE DIFFERENCES CALCULATED. THE LAST SET OF 5 PLOTS SHOWS THESE VALUES FOR THE 5 SSM/I CHANNELS: 19V, 19H, 22V, 37V AND 37H.

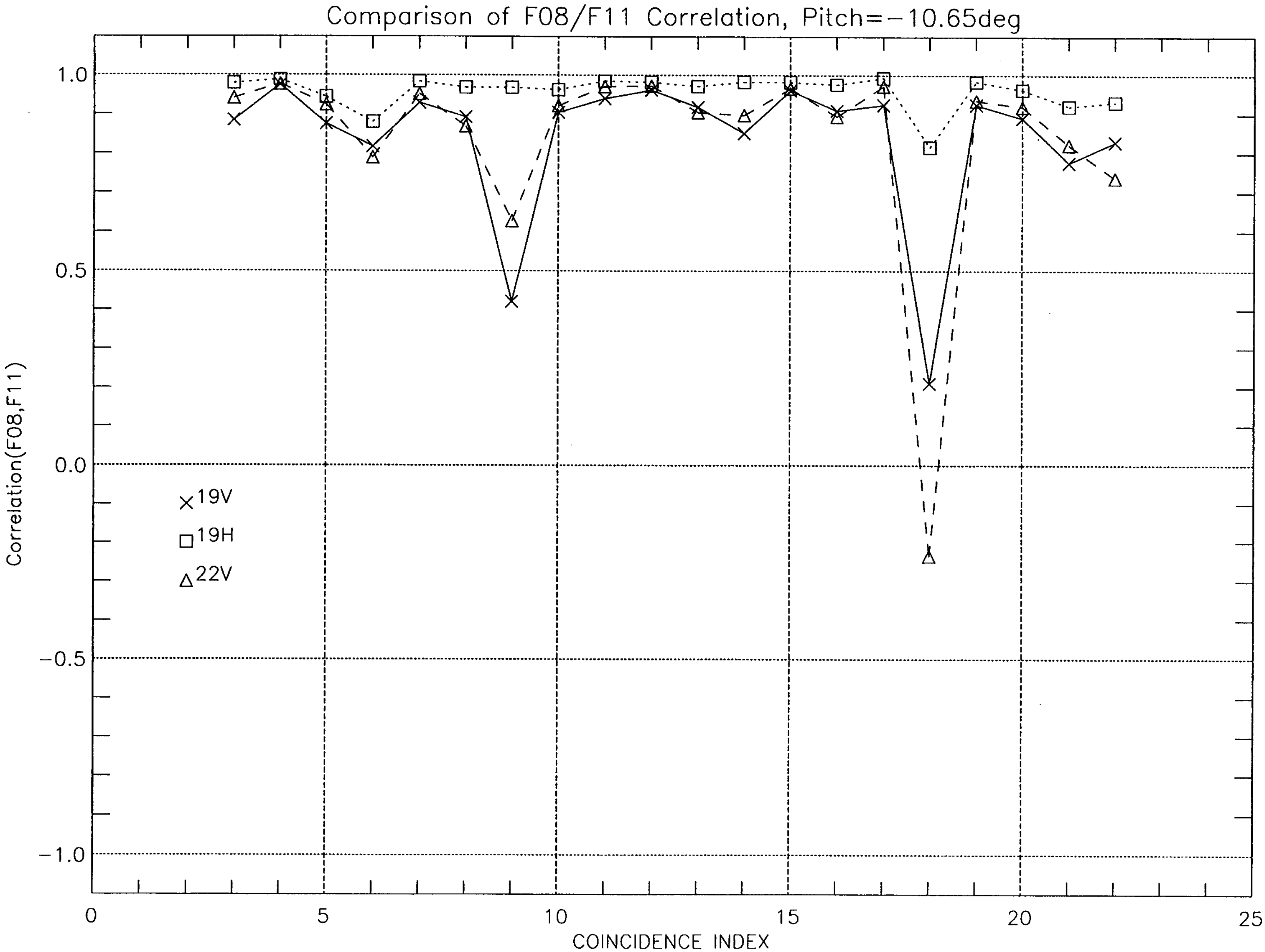


19V,H Channel Means, F08 & F11, −10.65deg
F08
F11
V−POL
H−POL
<TB> (K)
COINCIDENCE INDEX
300
200
100
0
5
10
15
20
25

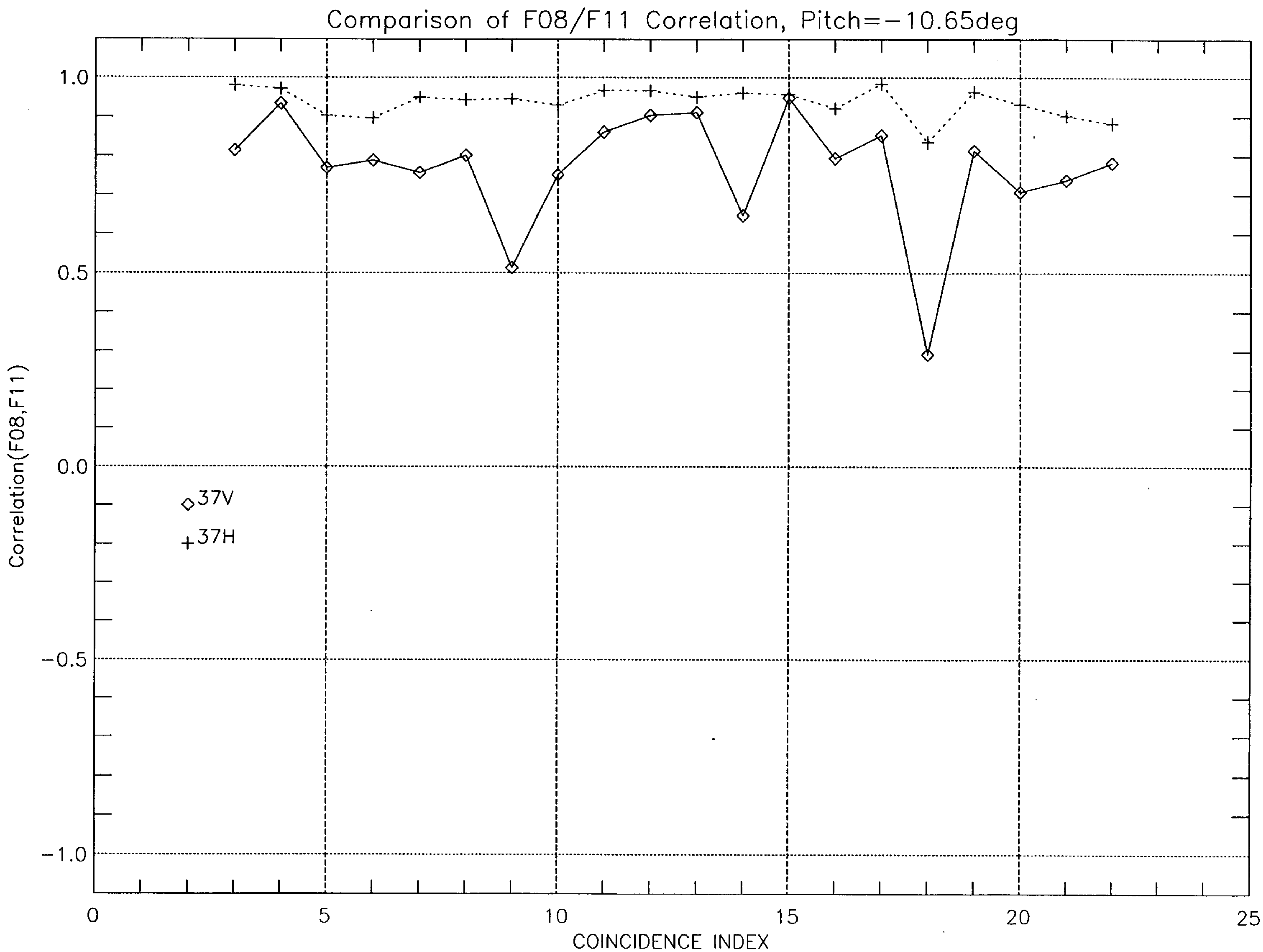


22V Channel Means, F08 & F11,-10.65deg
F08
F11
<TB> (K)
COINCIDENCE INDEX
V-POL
0
100
200
300
0
5
10
15
20
25

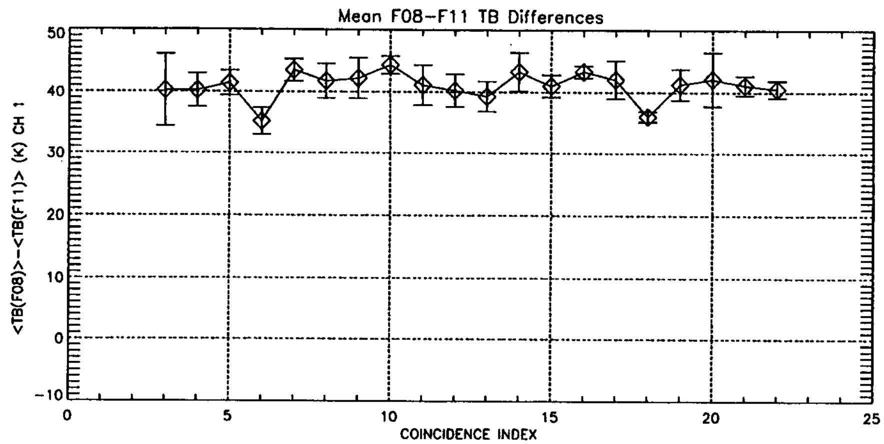

37V,H Channel Means, F08 & F11, -10.65deg
F08
F11
300
200
100
0
<TB> (K)
V-POL
H-POL
0
5
10
15
20
25
COINCIDENCE INDEX

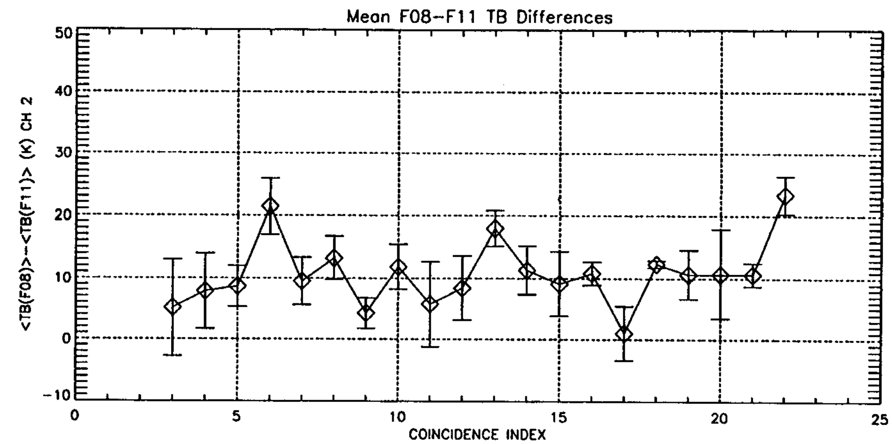


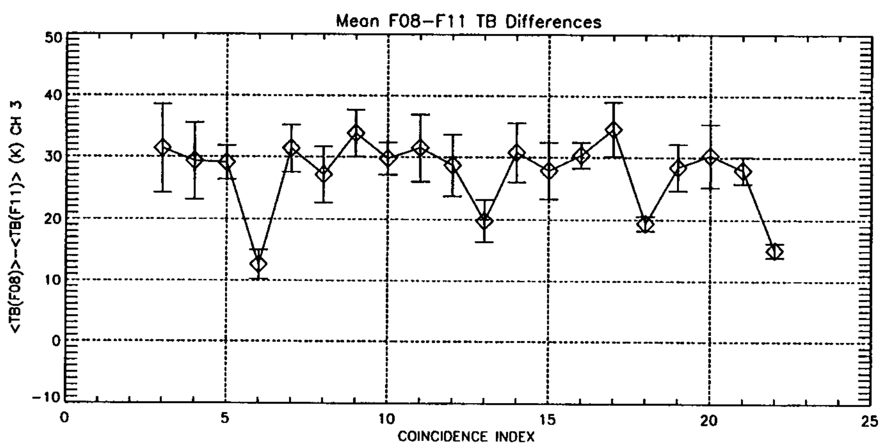
Comparison of F08/F11 Correlation, Pitch=−10.65deg
1.0
0.5
0.0
−0.5
−1.0
Correlation(F08,F11)
0
5
10
15
20
25
COINCIDENCE INDEX
19V
19H
22V

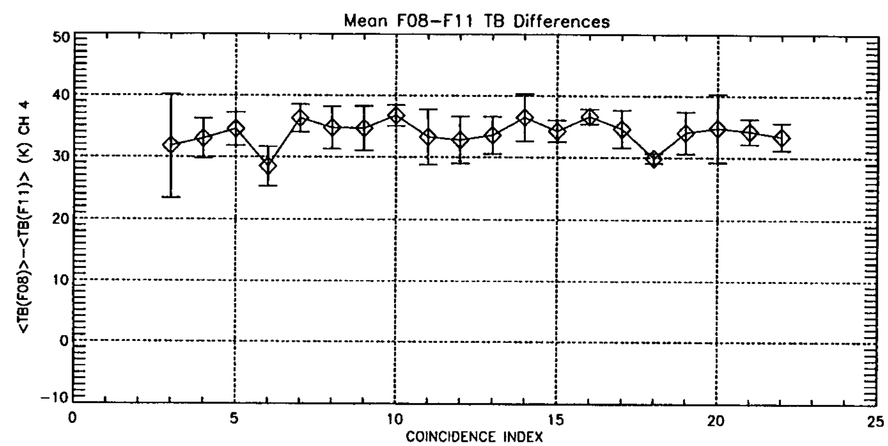


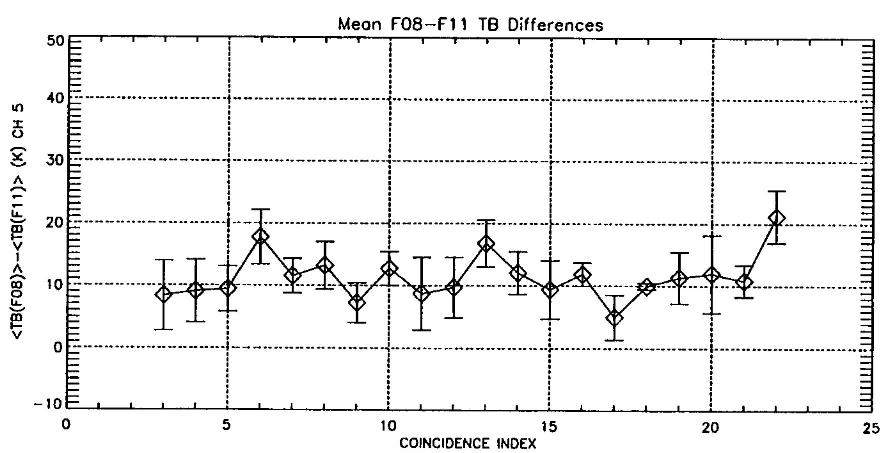
Comparison of F08/F11 Correlation, Pitch=-10.65deg
1.0
0.5
0.0
-0.5
-1.0
Correlation(F08,F11)
◇37V
+37H
0
5
10
15
20
25
COINCIDENCE INDEX


Mean F08-F11 TB Differences
<TB(F08)>-<TB(F11)> (K) CH 1
COINCIDENCE INDEX


Mean F08-F11 TB Differences
<TB(F08)>-<TB(F11)> (K) CH 2
COINCIDENCE INDEX


Mean F08-F11 TB Differences
<TB(F08)>-<TB(F11)> (K) CH 3
COINCIDENCE INDEX


Mean F08-F11 TB Differences
<TB(F08)>-<TB(F11)> (K) CH 4
COINCIDENCE INDEX


Mean F08-F11 TB Differences
<TB(F08)>-<TB(F11)> (K) CH 5
COINCIDENCE INDEX

DETAILED EXAMPLE
PITCH = –10.65°
31092/08159

THE FOLLOW CHARTS ILLUSTRATE ONE EXAMPLE OF THE DETAILED COMPARISON BETWEEN THE F08 AND F11 DATA FOR THE HIGH EIA CASE.

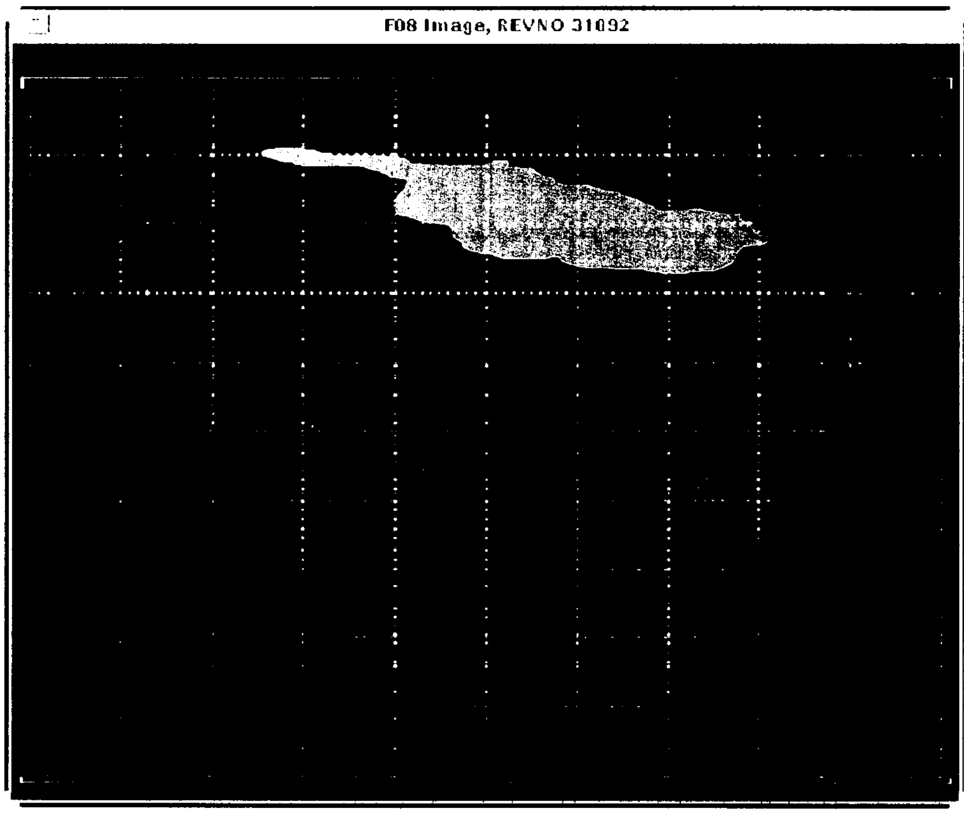
PAGE 80 SHOWS COINCIDENT F08 AND F11 DATA FOR THE 19V CHANNELS, MAPPED TO A MERCATOR PROJECTION. THIS IMAGE PAIR ILLUSTRATES THAT THE GROSS FEATURES ARE STILL EVIDENT WHEN COMPARING THE F08 DATA WITH THE F11 IMAGERY.

PAGE 81 SHOWS OCEAN SURFACE WIND SPEED AND ATMOSPHERIC WATER VAPOR DERIVED FROM THE F11 DATA. NOTE THAT WHEN WE COMPARE THE EDR DATA TO THE 19V DATA ON PAGE 78 IT APPEARS THAT THERE ARE TWO DISCERNIBLE REGIONS. THIS IS FURTHER ILLUSTRATED IN THE DATA PLOTS ON FOLLOWING PAGES.

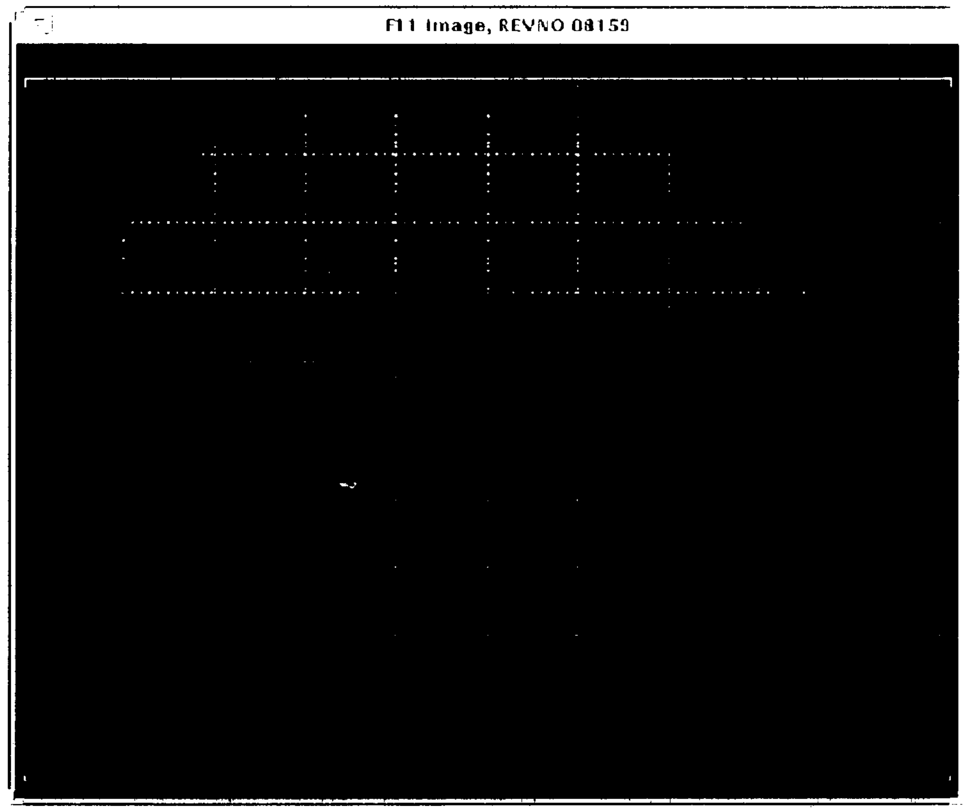
THE ORIGINAL IMAGES ARE IN COLOR SO THE FULL DETAIL MAY BE DIFFICULT TO ASCERTAIN IN A B/W PRINT.

COMPARISON OF F08 AND F11 BRIGHTNESS TEMPERATURES FOR 19V CHANNEL

F08 - 31092



F11 - 08159



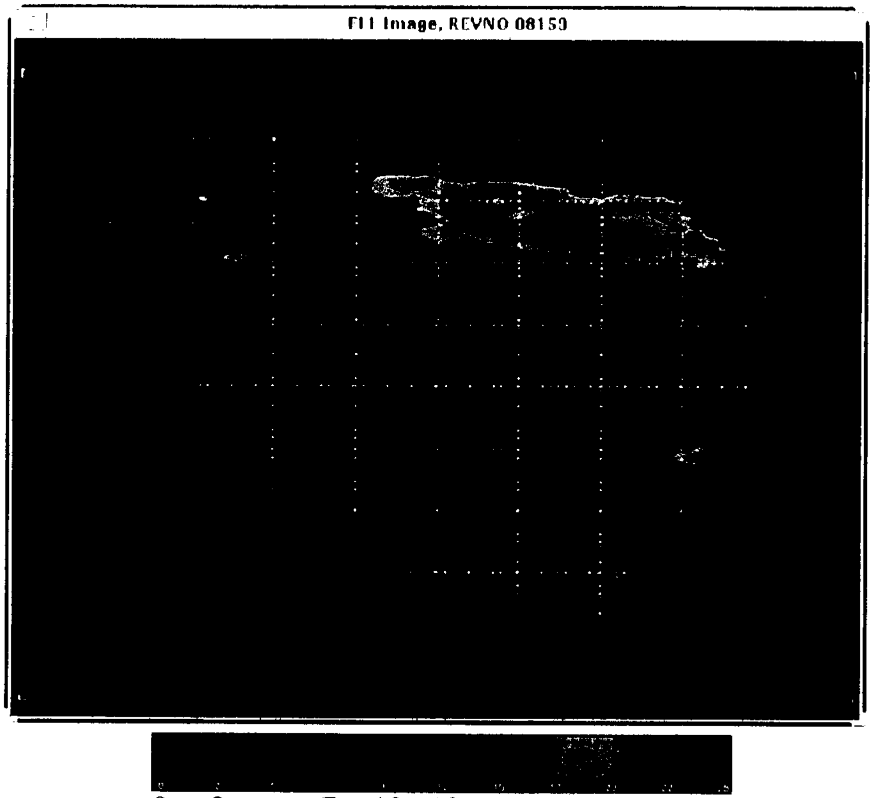
150 165 180 195 210 225 240 255 270 285 300 K

BRIGHTNESS TEMPERATURE

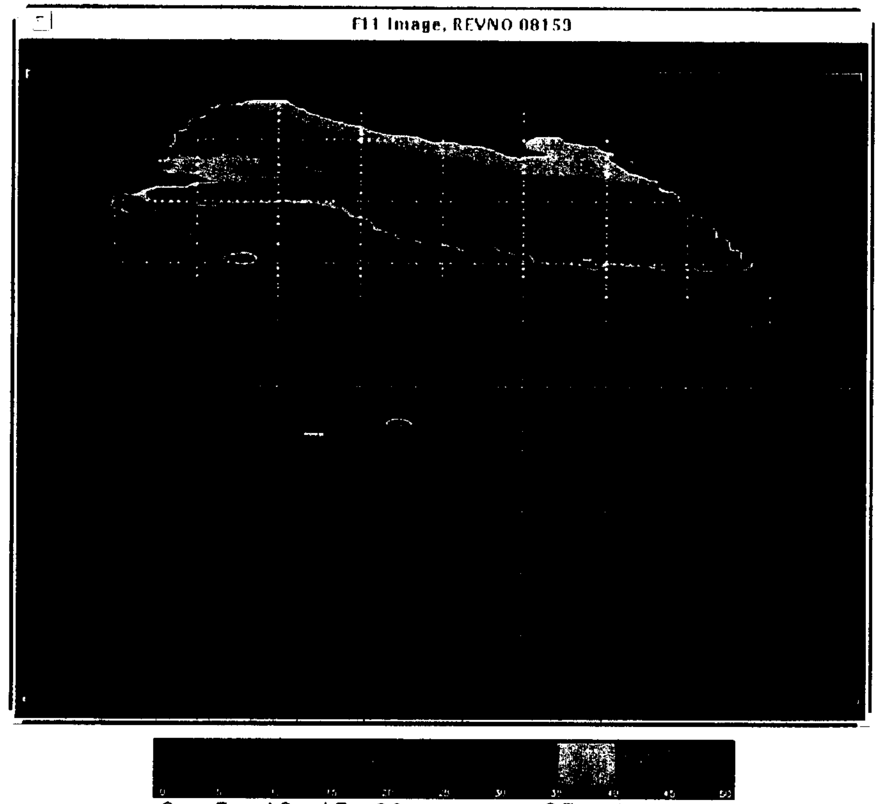
OCEAN SURFACE WIND SPEED AND WATER VAPOR EDRs

F08-31092
F11-08159

EDRs DERIVED FROM F11 SDR DATA



WIND SPEED (m/sec)



WATER VAPOR (kg/m2)

NOTE THAT THE MAXIMUM INTENSITY IN EACH CASE INCLUDES ALL VALUES ≥ THE MAXIMUM COLOR BAR VALUE. FOR THIS DATASET THIS INCLUDES INVALID AND OUT OF RANGE EDR PIXEL VALUES.

THE AEROSPACE CORPORATION

DETAILED EXAMPLE
PITCH = –10.65°
31092/08159

THE FOLLOWING CHARTS FURTHER ILLUSTRATE THE EXAMPLE OF THE COMPARISON BETWEEN THE F08 AND F11 DATA FOR THE HIGH EIA CASE.

PAGE 83A SHOWS A HISTOGRAM OF OCEAN SURFACE WIND SPEED, CLEARLY SHOWING A BIMODAL DISTRIBUTION . THE TWO DARK VERTICAL LINES CORRESPOND TO THE MEAN VALUES IN EACH CASE:

- $\langle U_W \rangle = 4.26 \pm 1.17$ M/SEC
- $\langle U_W \rangle = 11.66 \pm 1.89$ M/SEC

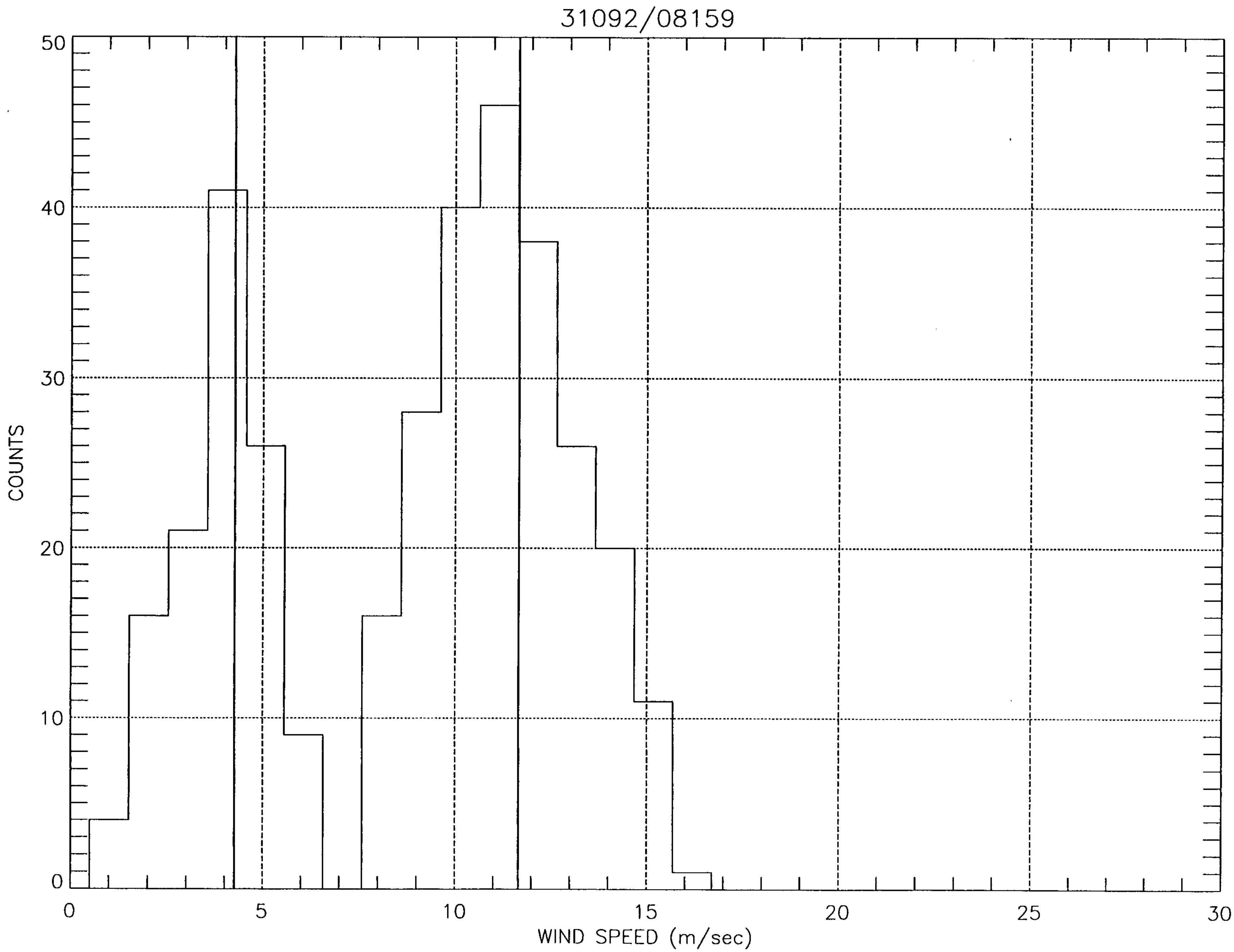
PAGE 83B SHOWS A HISTOGRAM OF THE TOTAL INTEGRATED WATER VAPOR, CLEARLY SHOWING A BIMODAL DISTRIBUTION . THE TWO DARK VERTICAL LINES CORRESPOND TO THE MEAN VALUES IN EACH CASE:

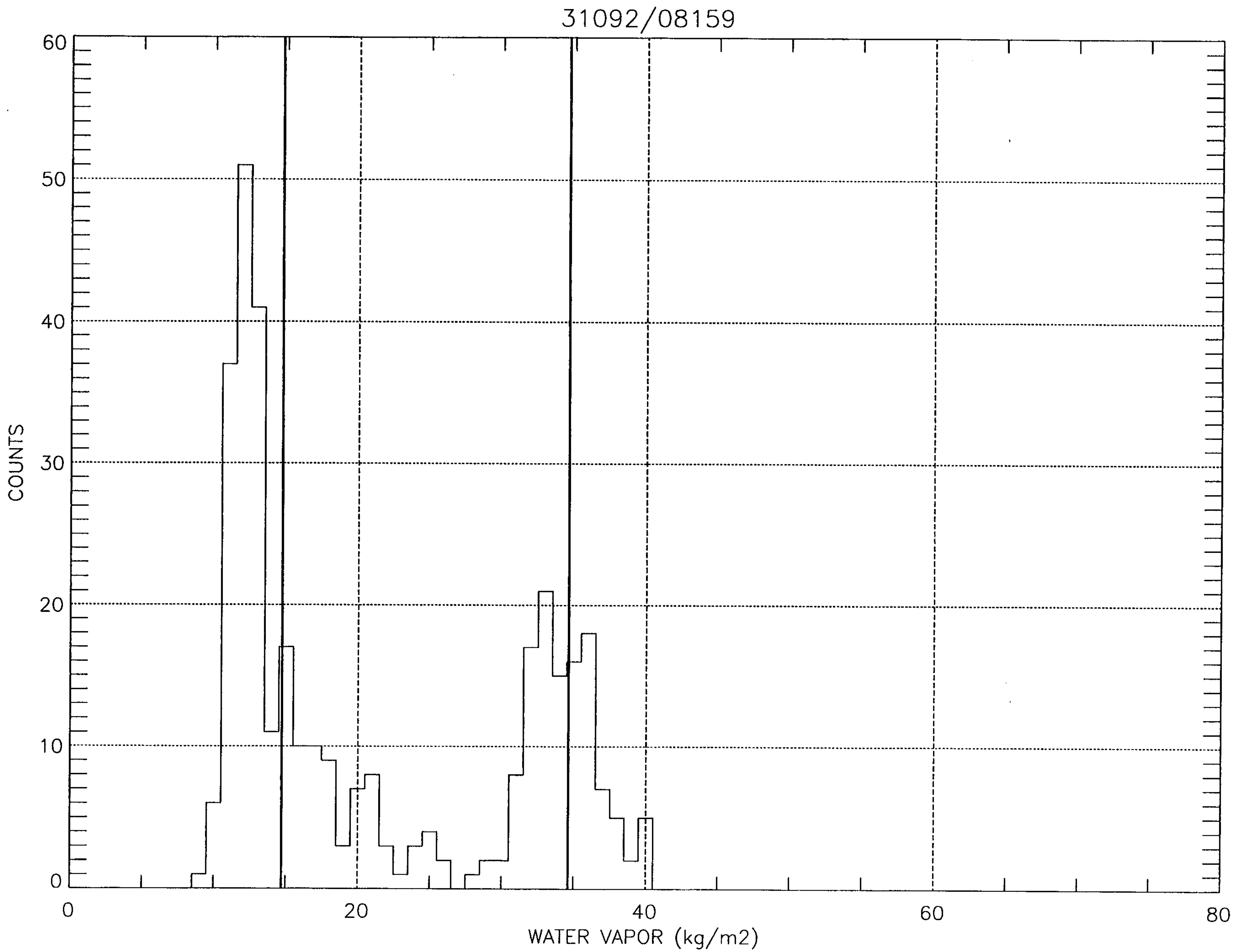
- $\langle WV \rangle = 34.63 \pm 2.35$ KG/M^2
- $\langle WV \rangle = 14.71 \pm 3.98$ KG/M^2

PAGE 83C SHOWS A SCATTER PLOT OF WV AS A FUNCTION OF WIND SPEED, ILLUSTRATING THE CORRELATION OF THE HIGH WATER VAPOR REGION WITH THE LOWER WIND SPEEDS.

PAGE 83D SHOWS THE CLOUD LIQUID WATER HISTOGRAM, INDICATING LITTLE CLOUD WATER.

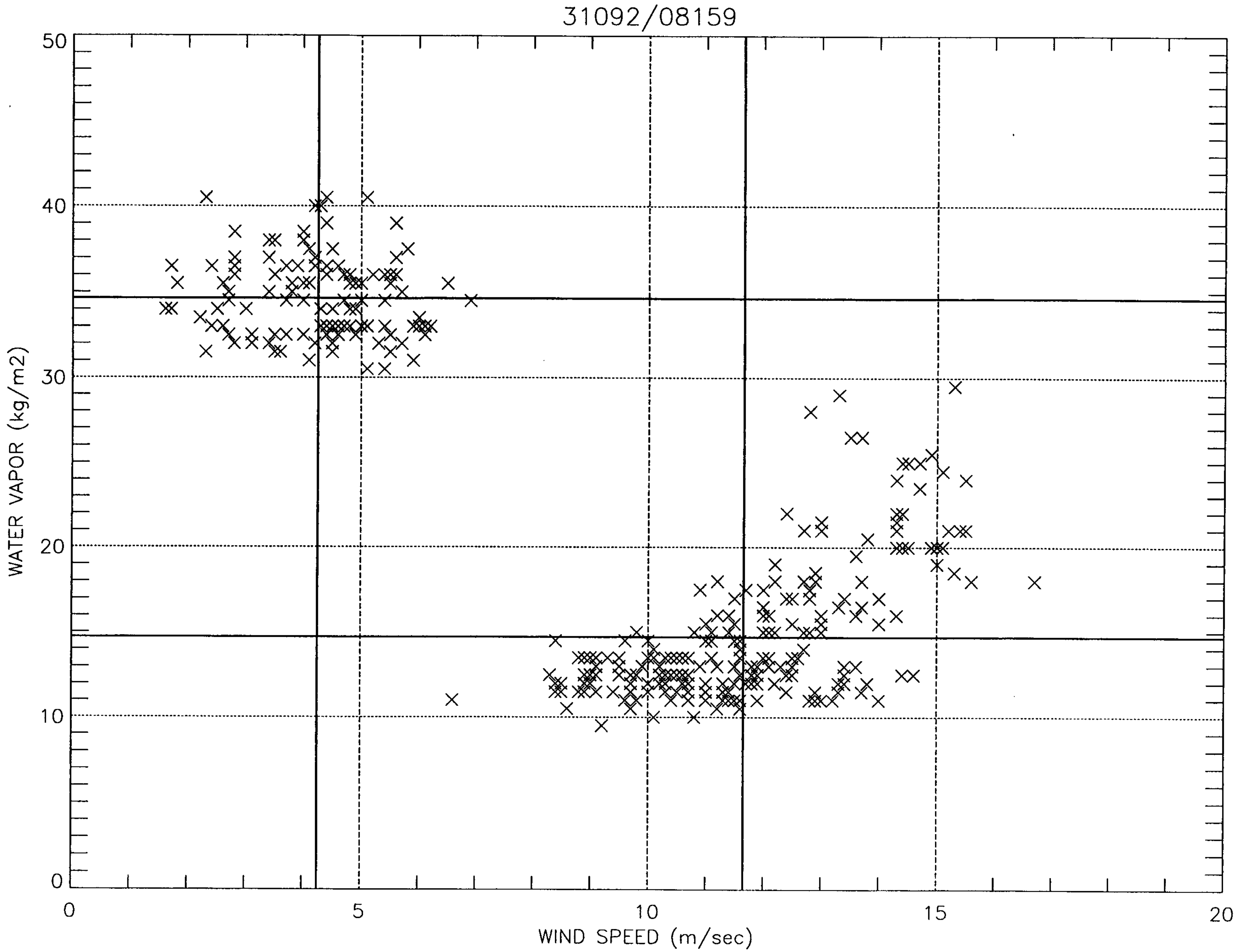
PAGES 83E–83M SHOW THE FOLLOWING SEQUENCE OF PLOTS FOR THE 19, 22 AND 37 GHz CHANNELS. THE FIRST PLOT IS A SCATTER PLOT OF THE V AND H BRIGHTNESS TEMPERATURES FOR THE F08 DATA AS A FUNCTION OF WIND SPEED. THE SECOND PLOT IS FOR THE F11 DATA. THE THIRD PLOT IN THE SEQUENCE IS A SCATTER PLOT OF THE F08 BRIGHTNESS TEMPERATURES FOR V AND H POLARIZATION AS A FUNCTION OF THE CORRESPONDING F11 BRIGHTNESS TEMPERATURES. FROM THESE PLOTS ONE CAN CLEARLY OBSERVE THE DIFFERENCES IN BRIGHTNESS TEMPERATURE DUE TO THE INCREASED EIA FOR THE F08 DATA. FURTHER STATISTICAL ANALYSIS OF THE DEPENDENCE OF BRIGHTNESS TEMPERATURE ON WIND SPEED WILL BE REPORTED IN THE FUTURE.


31092/08159
COUNTS
50
40
30
20
10
0
0
5
10
15
20
25
30
WIND SPEED (m/sec)

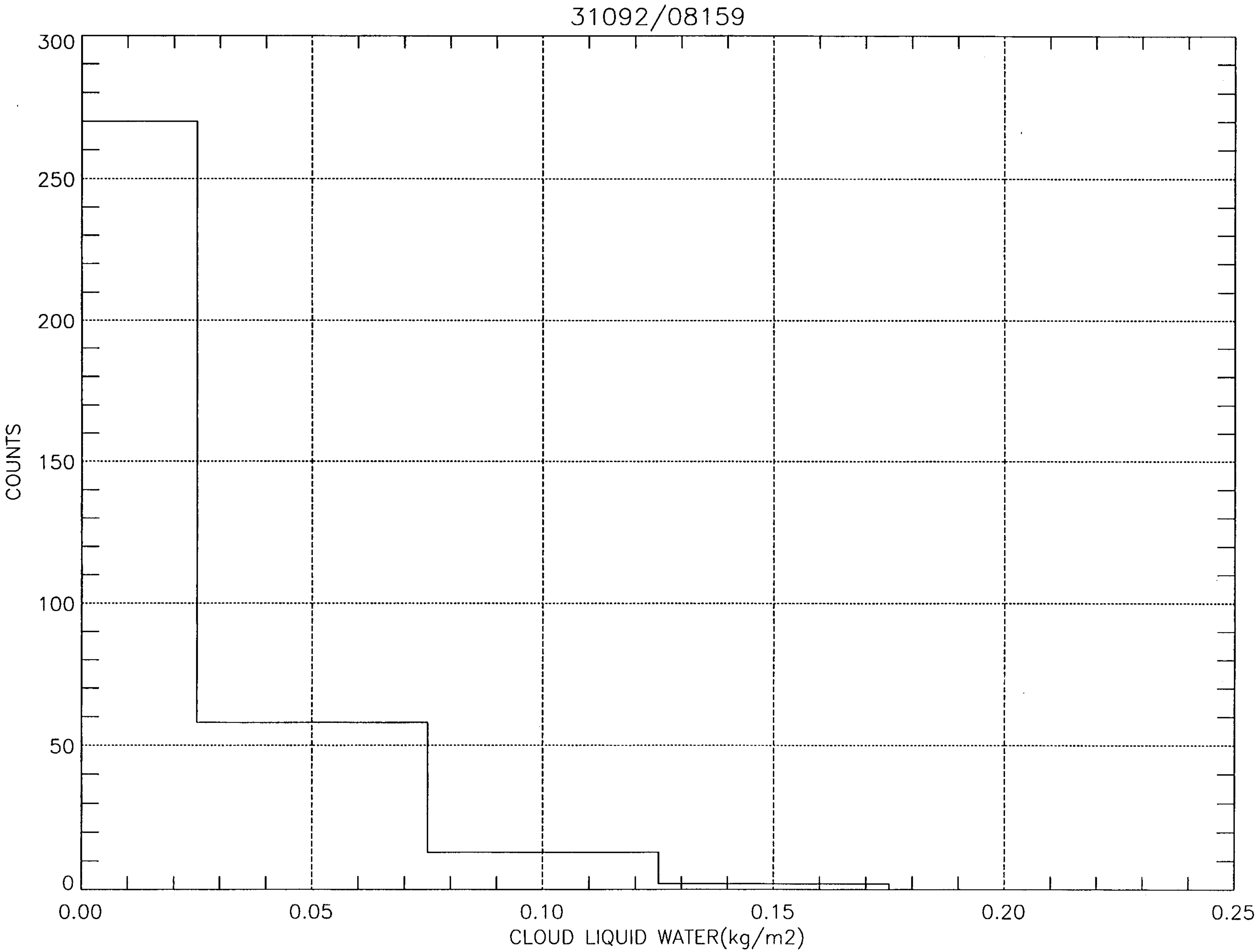


31092/08159
COUNTS
WATER VAPOR (kg/m2)
0
10
20
30
40
50
60
0
20
40
60
80

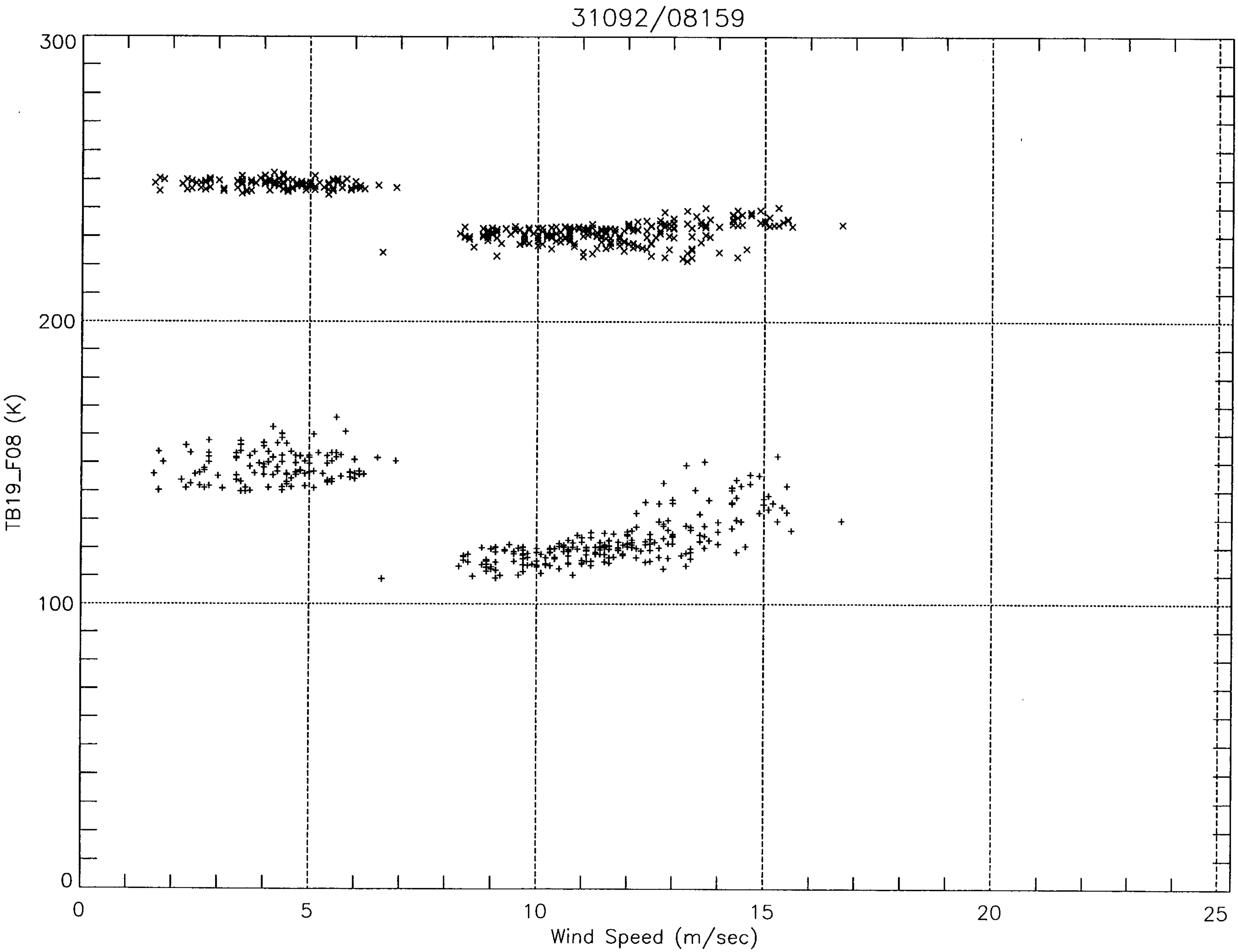
83B


31092/08159
WATER VAPOR (kg/m2)
WIND SPEED (m/sec)
0
10
20
30
40
50
0
5
10
15
20

83C

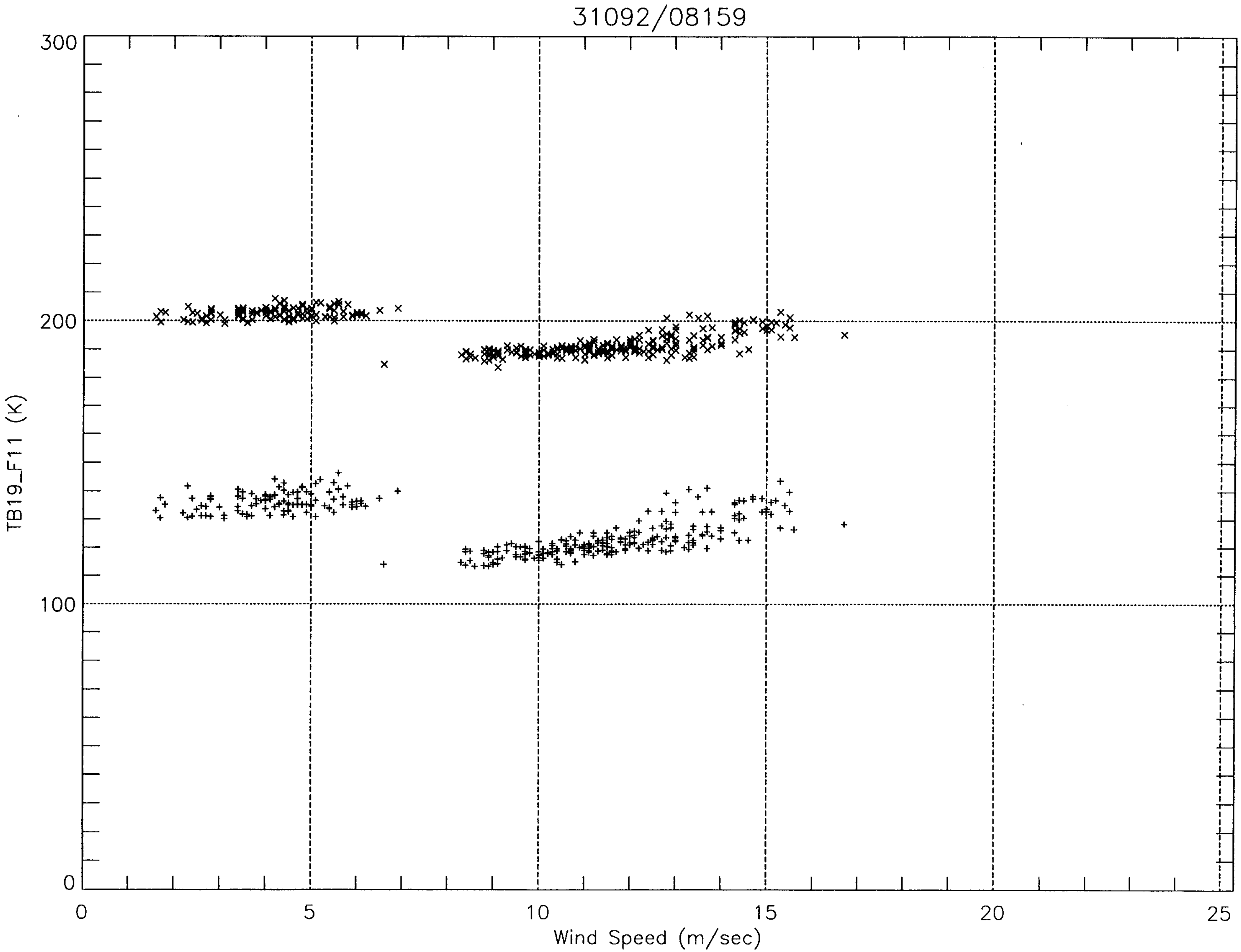

31092/08159
COUNTS
CLOUD LIQUID WATER(kg/m2)
0
50
100
150
200
250
300
0.00
0.05
0.10
0.15
0.20
0.25

83D

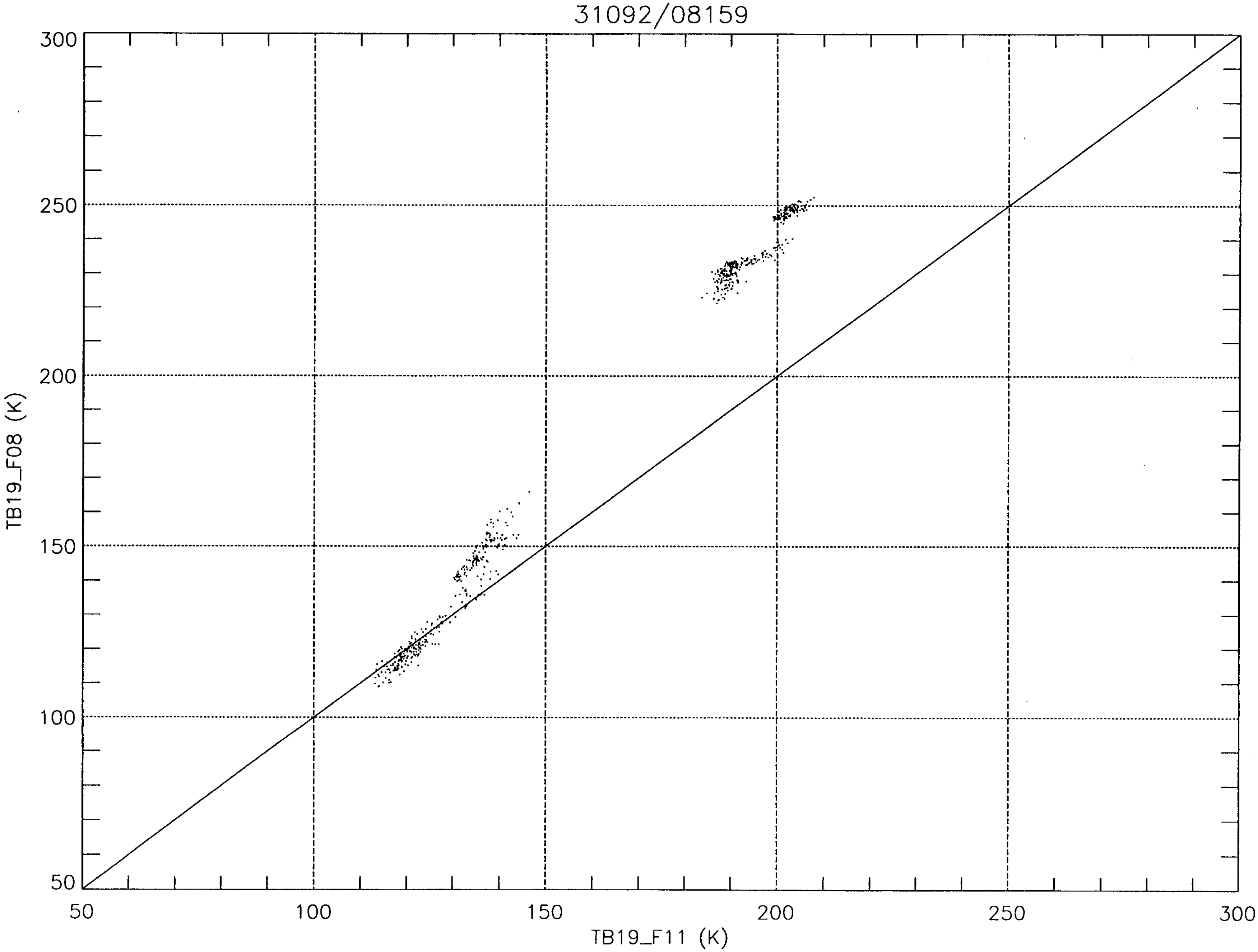


31092/08159
300
200
100
0
TB19_F08 (K)
0
5
10
15
20
25
Wind Speed (m/sec)

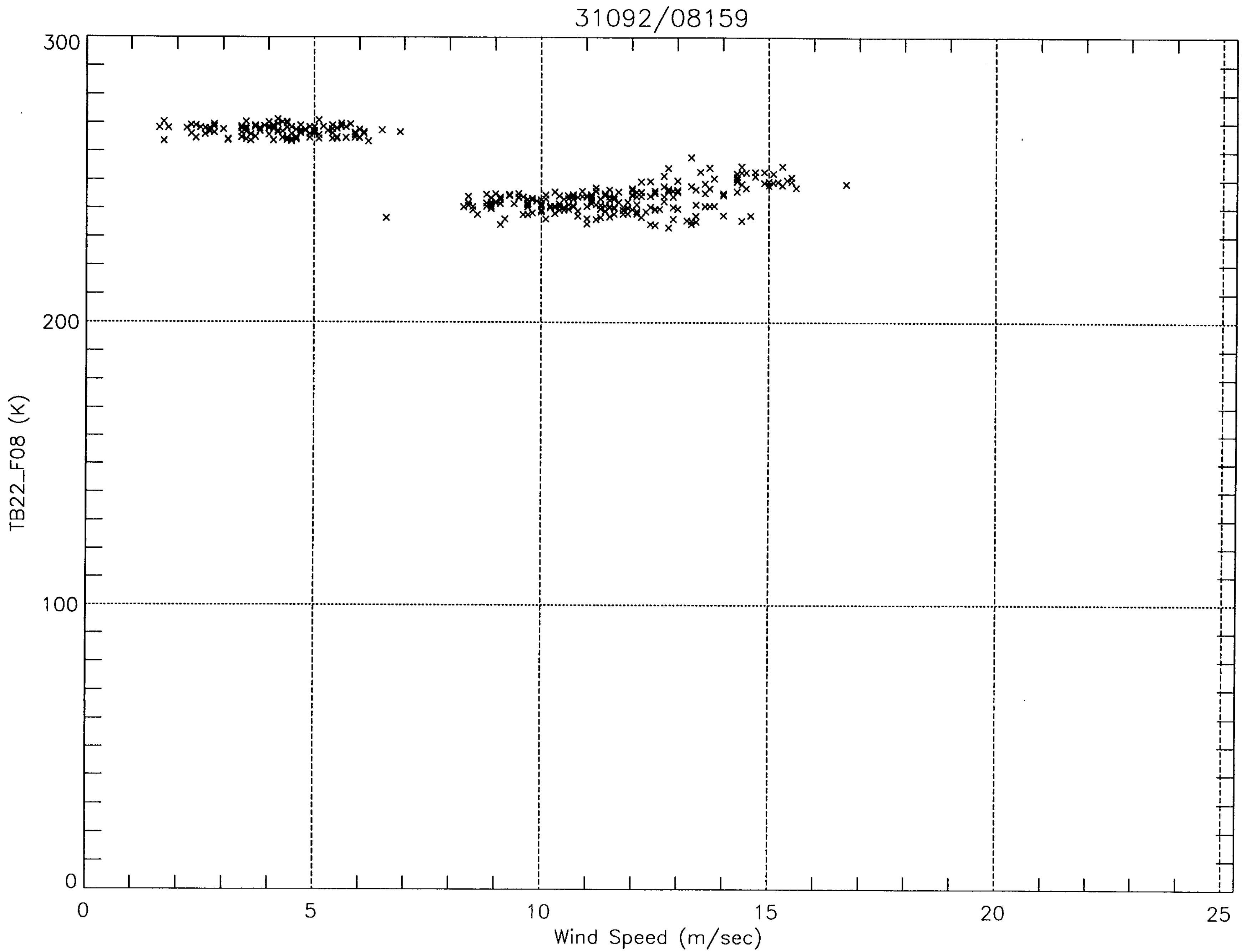
83E


31092/08159
300
200
100
0
TB19_F11 (K)
0
5
10
15
20
25
Wind Speed (m/sec)

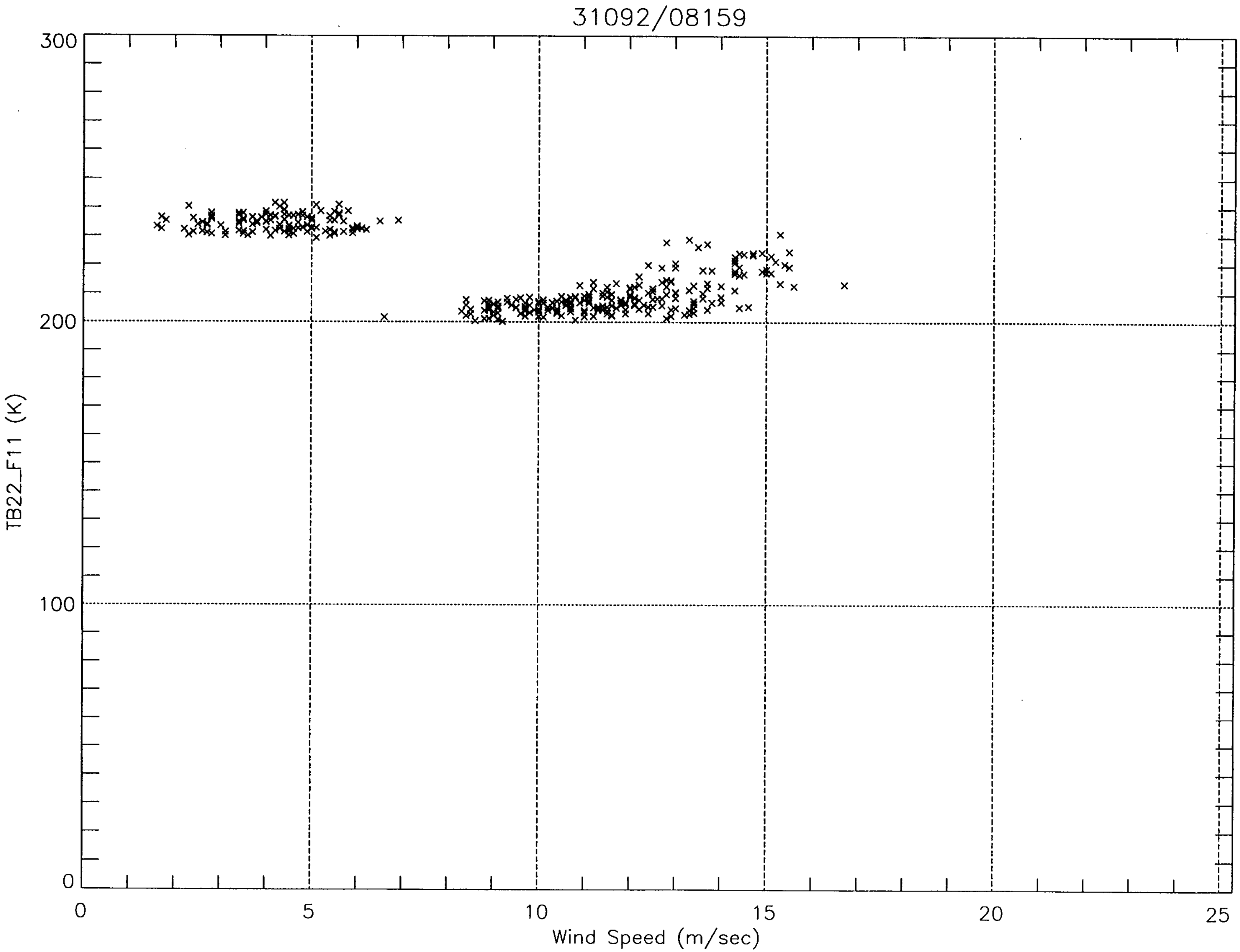
83F



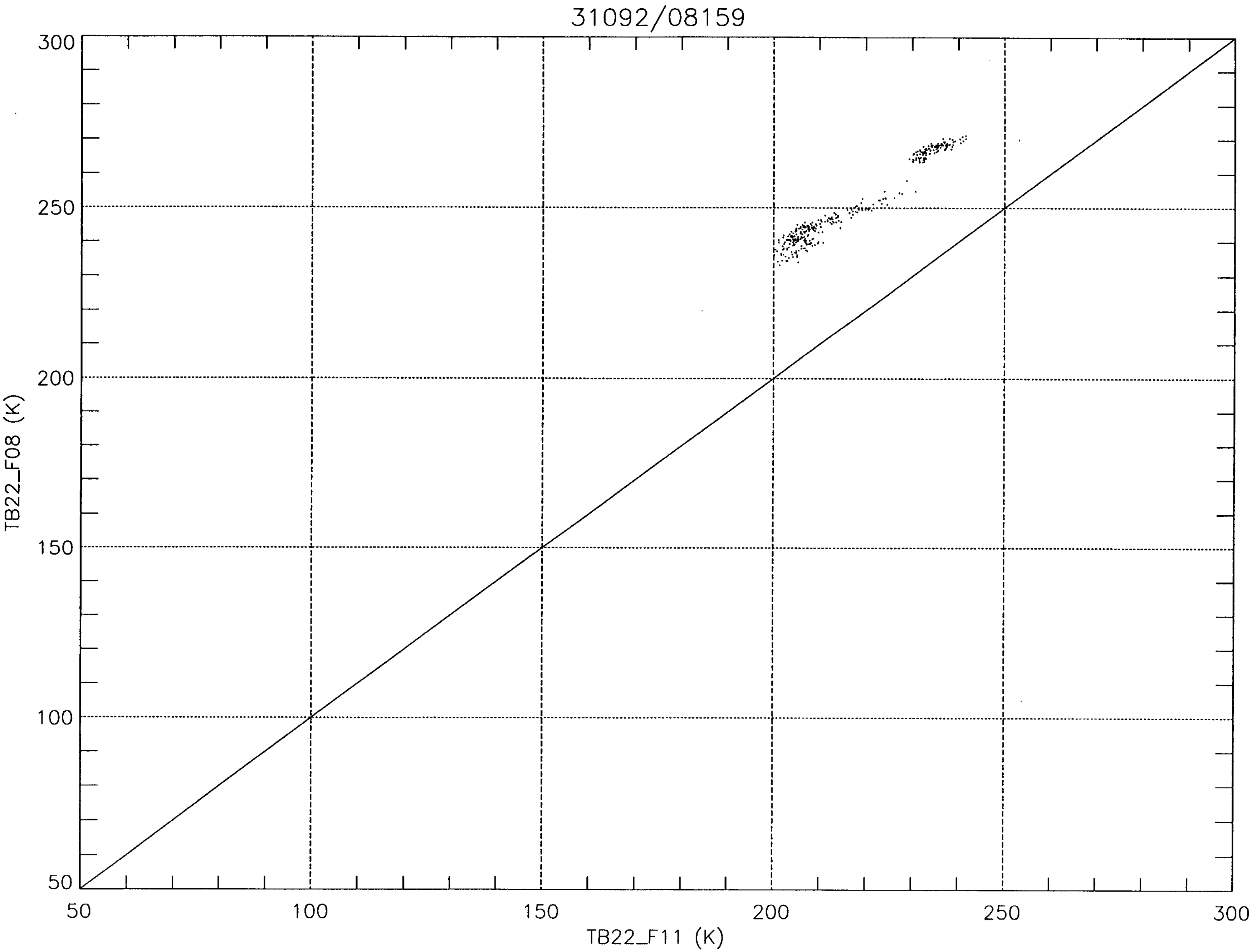
83G


31092/08159
TB22_F08 (K)
Wind Speed (m/sec)
0
100
200
300
0
5
10
15
20
25

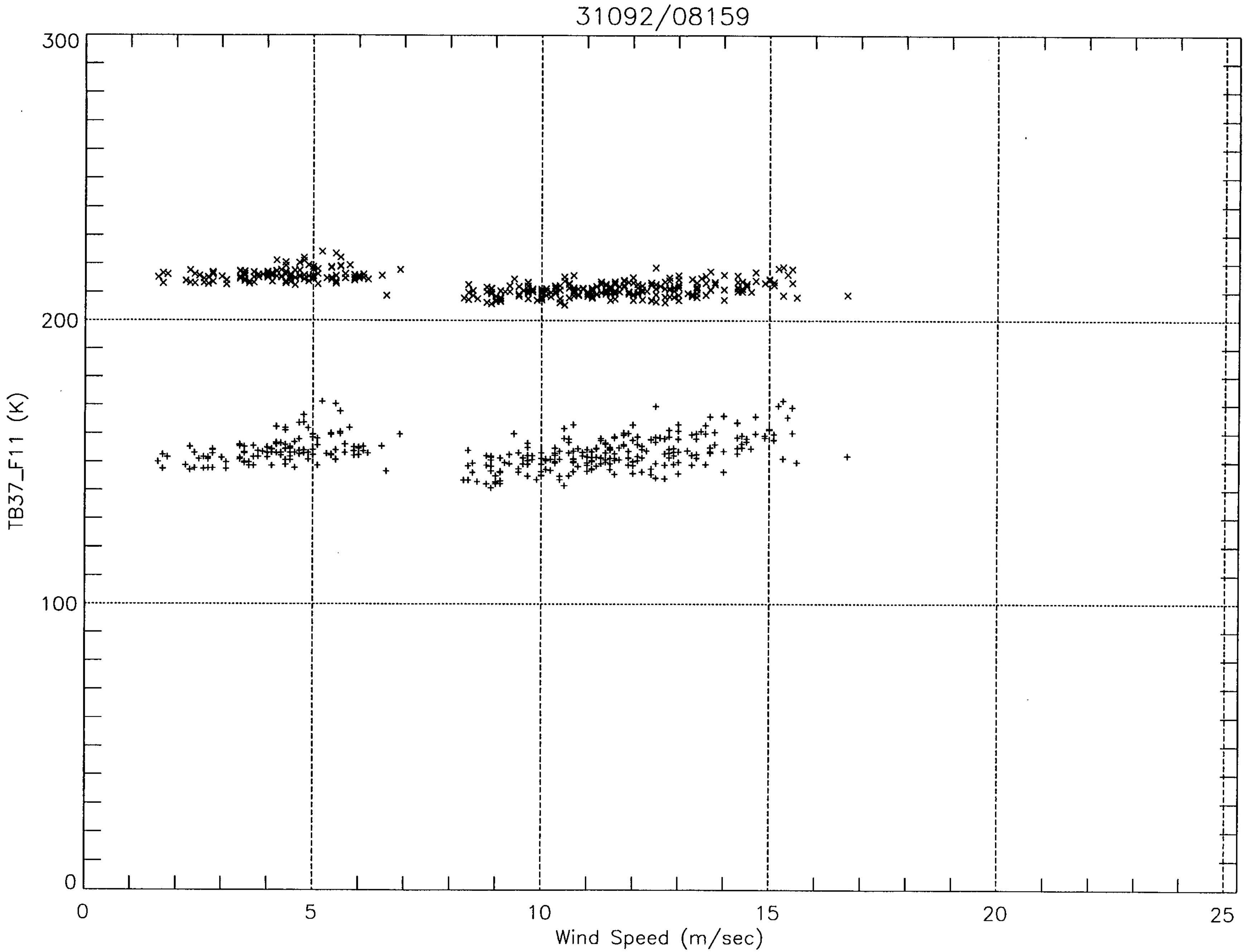
83H


31092/08159
TB22_F11 (K)
300
200
100
0
0
5
10
15
20
25
Wind Speed (m/sec)

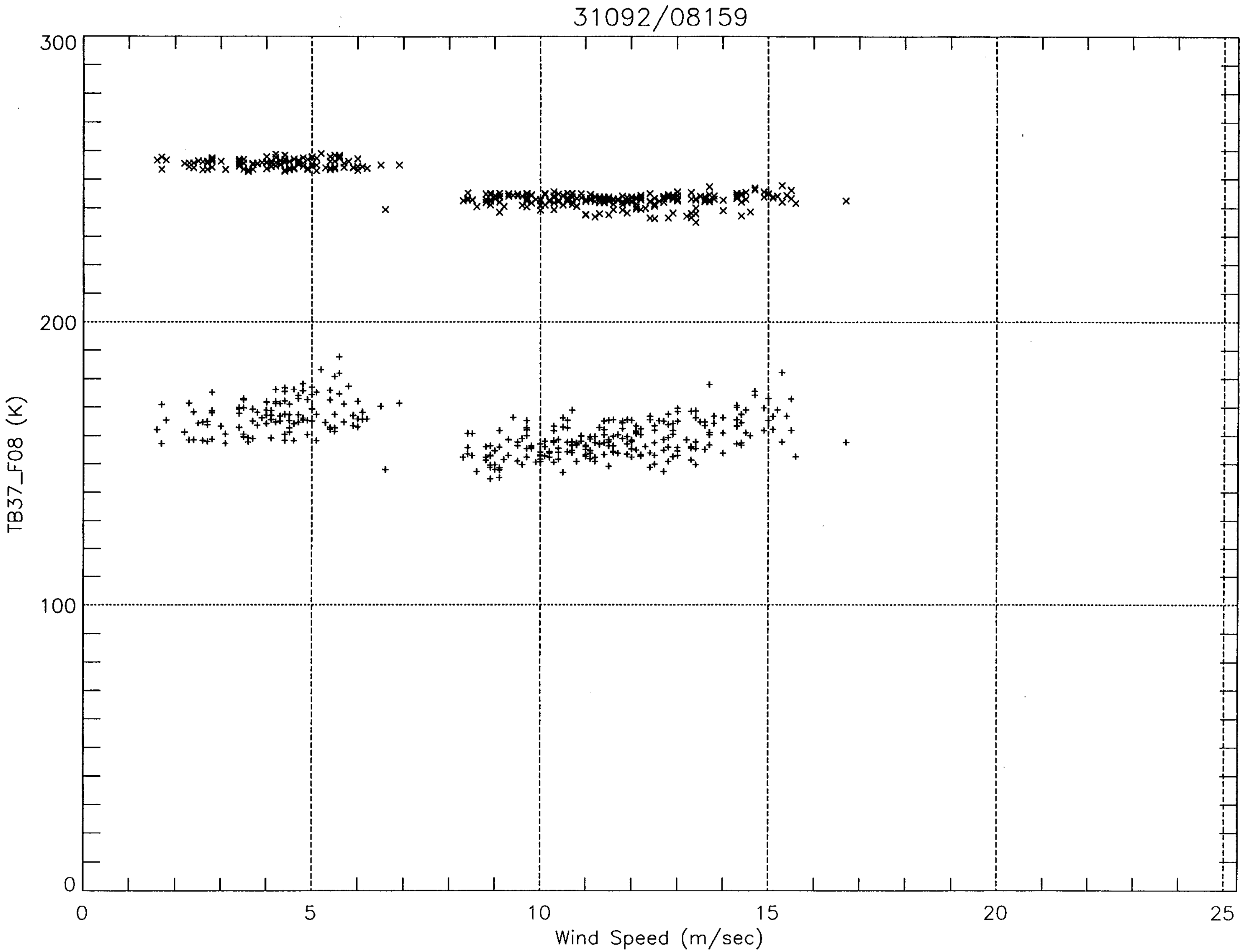
83I



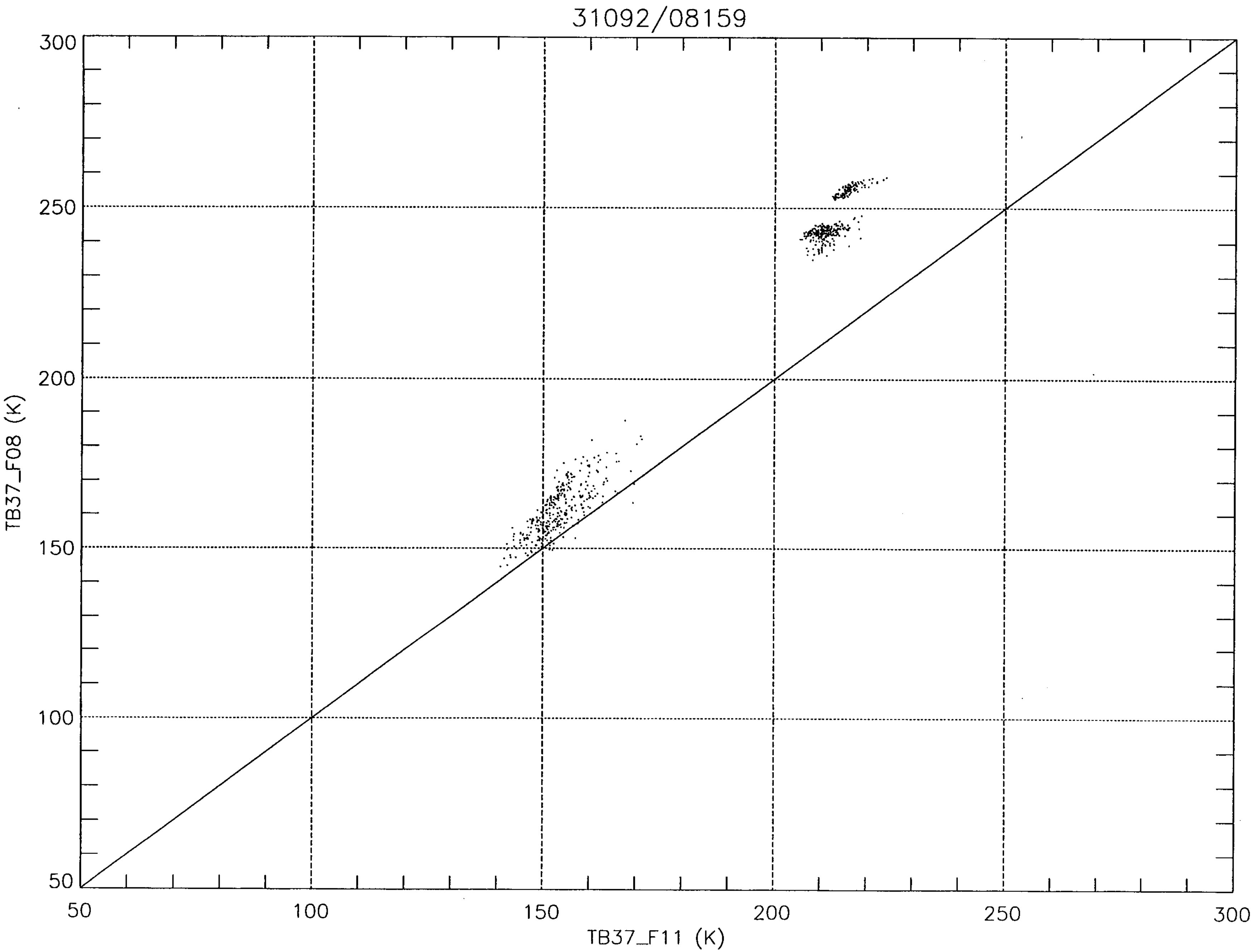
31092/08159
300
250
200
150
100
50
50
100
150
200
250
300
TB22_F08 (K)
TB22_F11 (K)


31092/08159
300
200
100
0
0
5
10
15
20
25
TB37_F11 (K)
Wind Speed (m/sec)

83K


31092/08159
TB37_F08 (K)
Wind Speed (m/sec)
0
100
200
300
0
5
10
15
20
25

83L


31092/08159
300
250
200
150
100
50
TB37_F08 (K)
50
100
150
200
250
300
TB37_F11 (K)

83M

COMPARISON OF F08 WITH F11
DISCUSSION OF RESULTS AND ISSUES

- **ISSUES**
  - IMAGERY
    - » CAN WE ACQUIRE QUALITY IMAGERY AT HIGH EIA?
    - » CAN WE MAINTAIN IMAGE QUALITY IN GOING FROM 53° TO 69° EIA?
  - T_B MEASUREMENTS
    - » IMPACT OF EIA ON SEPARATION OF SURFACE AND ATMOSPHERIC EMISSION
    - » REQUIREMENTS ON NEΔT
  - EDR RETRIEVALS
    - » OPTIMAL SELECTION OF CHANNELS AND REQUIRED RADIOMETRIC AND SPATIAL RESOLUTION/SAMPLING TO MEET EDR REQUIREMENTS
- **OTHER CONSIDERATIONS**
  - INCREASED SLANT RANGE MAGNIFIES ERRORS IN PLATFORM ATTITUDE AND POSITION — IMPACT ON GEOLOCATION
  - JPL WIND POLARIMETER MEASURES WIND SPEED AND DIRECTION
    - » RESULTS TO-DATE INDICATE BEST PERFORMANCE AT EIA<53°
- **RADIOMETER DESIGN IMPACTS**
  - SPATIAL RESOLUTION AND SAMPLING SHOULD BE INCREASED AT HIGH EIA, BUT MUST TRADE-OFF SIGNAL-TO-NOISE RATIO
  - IMPROVED NEΔT TO HELP OFFSET POSSIBLE DECREASED SENSITIVITY DUE TO INCREASED ATMOSPHERIC EMISSION/ABSORPTION

CONCLUSIONS

- **BASED ON THE ANALYSIS PERFORMED TO-DATE**
- **BASELINE COMPARISON VALIDATES SSM/I STABILITY AND INTERCOMPARISONS**
  - CAN BE USED TO REMOVE SENSOR BIAS

- **HIGH EIA DATA**
  - IMAGERY QUALITATIVELY CONFIRMS ABILITY TO OBSERVE FEATURES AT HIGH EIA — IN SPITE OF LOSS OF CONTRAST AND DEGRADED SPATIAL RESOLUTION
  - OVER OCEAN HIGH EIA DATA TRACKS BASELINE VERY WELL, OVER A RANGE OF CONDITIONS AND LOCATIONS

- **FURTHER ANALYSIS NEEDED TO LOOK AT DETAILED STATISTICAL BEHAVIOR OF T_B**
  - DEPENDENCE ON
    - » SW: OCEAN SURFACE WIND SPEED
    - » WV: TOTAL ATMOSPHERIC WATER VAPOR
    - » CLW: CLOUD LIQUID WATER

PLANS FOR CONTINUED ANALYSIS OF F08TEX DATA

- FINISH ANALYSIS OF –10.65° DATA
  - FINISH STATISTICAL ANALYSIS OF T_B VARIATION WITH SW, WV AND CLW
  - ASSESS ANOMALIES
  - MORE DETAILED MODEL COMPARISON — BASED ON EDR INFORMATION
  - INCLUDE F10 DATA
  - WRITE TOR ON HIGH EIA RESULTS
- EDR RETRIEVAL AND MODEL ANALYSIS
  - USING GENERAL PROCEDURE SIMILAR TO CAL/VAL DEVELOP A RETRIEVAL ALGORITHM FOR OCEAN SURFACE WIND USING PITCHED F08 DATA AND F11 AS "TRUTH"
  - FOR SELECTED AREAS PERFORM DETAILED MODEL ANALYSIS AND COMPARISON WITH F08TEX DATA
- ANALYZE DATA AT REMAINING PITCH ANGLES
  - IN PARTICULAR –8° PITCH —LARGE NUMBER OF COINCIDENCES
- COMPARE F08 WITH F10
- COMPARISON WITH GROUND TRUTH DATA
  - OCEAN SURFACE BUOYS
  - MCSST SEA SURFACE TEMPERATURE FIELDS FROM NAVY
  - ATMOSPHERIC SOUNDINGS

GLOSSARY

AES	Aerojet Electra-Systems
AFGWC	Air Force Global Weather Central
APC	Antenna Pattern Correction
Cal/Val	Calibration/Validation
CLW	Cloud Liquid Water
DEF	Data Exchange Format
DEG	Degrees
DMSP	Defense Meteorological Satellite Program
EDR	Environmental data record
EIA	Earth incidence angle
ESA	European Space Agency
F08TEX	F08 Tilt Experiment
FNOC	Fleet Numerical Oceanography Center
FNOMC	Fleet Numerical Oceanography and Meteorological Center
IDL	Interactive Data Language
JPL	Jet Propulsion Laboratory
LMSC	Lockheed Missile and Space Company
MAX	Maximum
MCSST	Multi-Channel Sea Surface Temperature
MIN	Minimum
MMAS	Martin Marietta Astro-Space
NEDT	Noise Equivalent Temperature Difference
NRL	Naval Research Laboratory
PO	Program Office
PPT	Parts Per Thousand
QDR	Quality Data Record
SDR	Sensor data record
SMC	Space and Missile Systems Center
SPO	Special Program Office
SSM/I	Special Sensor Microwave Imager
S/C	Spacecraft
STDEV	Standard Deviation
SW	Surface Wind (ocean)
TDR	Temperature data record
TOR	Technical Operating Report
TWV	Total Integrated Water Vapor
USAF	United States Air Force
WV	Water Vapor

INTERNAL DISTRIBUTION LIST

REPORT TITLE
DMSP F08 TILT EXPERIMENT DATA ANALYSIS STATUS BRIEFING

REPORT NO. TOR-95(5478)-4	PUBLICATION DATE March 1, 1995	SECURITY CLASSIFICATION Unclassified

1. FOR OFF-SITE PERSONNEL, SHOW LOCATION SYMBOL, e.g., JOHN Q. PUBLIC/VAFB

2. IF LIST IS ALTERED, INITIAL CHANGE(S) AND SHOW AFFILIATION.

* FOR SECRET REPORTS SHOW BLDG AND ROOM, NOT MAIL STATION

NAME (INCLUDE INITIALS)	MAIL CODE *
N. Baker	M8-716
J. Bohlson	MS-715
M. Bolla	M4-904
D. Boucher	MS-715
S. Danahy	M4-041
J. De Lorenzo	M8-717
F. De Luccia	M8-716
H. Featherstone	M8-7 19
S. Gasster (5)	M4-927
D. Glackin	Ml-l 19
E. Hazelton	M4-927
G. Iwanaga	M8-7 17
T. Koegel	M8-7 15
J. Pranke	FAIR 78
D. Rudy	M4-902
F. Sanner	HERN
C. Selvey	M8-716
J. Straus	M4-933
B. Thomas	OMAHA
B. Wagoner	M8-715

NAME (INCLUDE INITIALS)	MAIL CODE *

APPROVED BY D. Dehaney DATE 26 May 1995

IF LIST COMPRISES TWO OR MORE SHEETS, COMPLETE ABOVE BLOCK ON LAST SHEET ONLY

AEROSPACE FORM 2394 REV 3-85

SHEET 1 OF 1

EXTERNAL DISTRIBUTION LIST

REPORT TITLE
DMSP F08 TILT EXPERIMENT DATA ANALYSIS STATUS BRIEFING

REPORT NO.	PUBLICATION DATE	SECURITY CLASSIFICATION
TOR-95(5478)-4	March 1, 1995	Unclassified

MILITARY AND GOVERNMENT OFFICES	ASSOCIATE CONTRACTORS AND OTHERS

1. SHOW FULL MAILING ADDRESS: INCLUDING ZIP CODE, MILITARY OFFICE SYMBOL, AND "ATTENTION" LINE
2. IF LIST IS ALTERED, INITIAL CHANGE(S) AND SHOW AFFILIATION

Lt. Col. E. Arrance	SMC/CIA
Capt. M. Crison	SMC/CIB
Col. Goyette	SMC/CI
Lt. R. Lew (5)	SMC/CIB
Capt. J. Vasquez	SMC/CIB

CMDR. L. Burgess
NAVY (CIN ATTN: PMW)
165-4 1, CMDR. BURGESS
Naval Warfare Systems Command
245 1 Crystal Drive
Arlington, VA 22245-5200

Dr. Marie Colton
Satellite Oceanographer
FNOC Bldg 702
7 Grace Hopper Road
stop 1
Monterey, CA 93943

Gene Poe
Naval Research Laboratory
Code 7211
Bldg 58, Rm 225
4555 Overlook Ave. SW
Washington, DC 20375

Vince Falcone
Phillips Laboratory/GPAB
29 Randolph Rd.
Hanscom AFB, MA 0143 l-3010

DISTRIBUTION LIMITATIONS MARKED ON THE COVER/TITLE PAGE ARE AUTHORIZED BY SIGNATURE BELOW

APPROVED BY (AEROSPACE) ______ DATE 26 May 1995

APPROVED BY (AF OFFICE) ______ DATE 26 MAY 95

(NOT REQUIRED FOR ATR CATEGORY)

IF LIST COMPRISES TWO OR MORE SHEETS, COMPLETE ABOVEBLOCKONLASTSHEEI'ONLY

AEROSPACE FORM 2380 REV 11-85

SHEET 1 OF 1